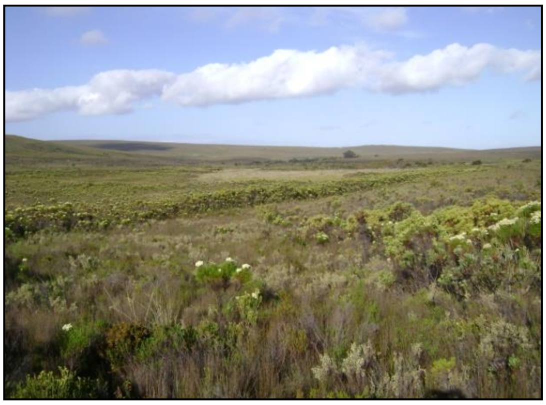
ENVIRONMENTAL IMPACT ASSESSMENT FOR THE PROPOSED NUCLEAR POWER STATION ('NUCLEAR 1') AND ASSOCIATED INFRASTRUCTURE

Wetland Ecosystems Specialist Study
Impact Assessment Phase

Prepared by: Liz Day (Freshwater Consulting Group)

Prepared for: Arcus GIBB Pty Ltd

On behalf of: Eskom Holdings Ltd

6 Flamingo Crescent
Zeekoevlei
7941

E-mail: lizday@mweb.co.za
VAT No: 444 024 7122

30 March 2011

DECLARATION OF INDEPENDENCE

I, Elizabeth (Liz) Day as a partner of Freshwater COnsulting cc (t/a The Freshwater Consulting Group / FCG), hereby confirm my independence as a specialist and declare that I do not have any interest, be it business, financial, personal or other, in any proposed activity, application or appeal in respect of which Arcus GIBB was appointed as environmental assessment practitioner in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998), other than fair remuneration for worked performed, specifically in connection with the Environmental Impact Assessment for the proposed conventional nuclear power station ('Nuclear 1'). I further declare that I am confident in the conclusions I have drawn from the studies undertaken – to the levels stated in my attached report.

____

Full Name: Elizabeth Day
Freshwater Consulting Group
lizday@mweb.co.za

Title / Position: Dr
Qualification(s): BA, BSc, BSc Hons, PhD
Experience: 15 years in freshwater ecosystems
Registration(s): Member of IAIA; Member of SAIEES; Registered Professional Natural Scientist by SACNASP (Reg No 400270/08) for fields of Biological Science, Ecological Science and Zoological Science

EXECUTIVE SUMMARY

E1 Introduction

This section is intended to provide a short summary of the major implications of the proposed Nuclear Power Station (NPS) development for wetlands at three alternative sites – Duynefontein, Bantamsklip and Thyspunt. All of the site alternatives include in their boundaries and immediate surroundings wetland systems that are of high ecological importance, relatively unimpacted and considered to be either among the last (in the case of Duynefontein) remnants of particular wetland habitats that have been lost from large areas or, in the case of Bantamsklip and particularly Thyspunt, they are considered unique systems that are unlikely to be represented in their present form and complexity elsewhere in the world. The conservation status of all three sites, from a wetlands perspective, is extremely high and any threats to their integrity are viewed as of high negative significance.

The report on which this summary is based has taken cognisance of the outcomes of a year of intensive groundwater and surface water monitoring and analysis (Visser *et al*. 2011) which have resulted in higher levels of confidence being accorded to predictions of the impacts of proposed activities associated with the development of a NPS, on wetlands at each of the three potential sites. Some of the conclusions of this report have thus changed substantially from those reflected in previous versions (e.g. Day 2009 and 2010).

E2 Impacts associated with the proposed NPS

The relative impacts of the proposed NPS development on wetlands vary considerably between site alternatives, depending on the proximity of each site to the wetlands, as well as on the sensitivity of groundwater / surface water interactions across the sites. The main impacts assessed are summarised below.

E2.1 Duynefontein

The main impacts associated with development of a single phase NPS at this site comprise a low likelihood of potential degradation of or disturbance to the artificial wetlands in the north west of the site, the transient duneslack wetlands of the mobile dune and an isolated seasonal wetland potentially in the vicinity of a proposed access road. The "recommended" (or least sensitive) development area for the proposed plant lies well away from the most sensitive wetlands on the site – that is, the duneslack depressional wetlands in the south western portion of the site. Groundwater modelling associates a low level of draw-down risk to both these and other wetlands on the site, as a result of dewatering.

Without the implementation of mitigation measures, the implications of development of a single NPS at Duynefontein have been assessed as of medium negative significance from a wetland perspective.

E2.2 Bantamsklip

The "recommended" (or least sensitive) development area for the proposed EIA and HV corridors at this site lie to the south of the R43 road through the site. The road itself acts as a barrier to the northern portion of the site, within which the critically important Groot Hagelkraal River and its associated hillslope seeps and valley bottom wetland tributaries occur. A major assumption of the EIA assessment of this site is that activities associated with the construction and operational phases of a NPS would be confined to the area south of the R43. This means that impacts to wetland systems resulting from the proposed project would be largely avoided. The following are the main areas of concern:

- Increased traffic on the R43, leading to fragmentation of wetland corridors
- Potential wetland degradation depending on the siting of NPS administration buildings
- Potential side-effects of increased development in the Pearly Beach area.

Of these, assessment of the latter falls outside of the scope of this study. The issue is nevertheless highlighted.

The geohydrological study (Visser et al. 2011) indicated that although the radius of draw-down associated with dewatering of this site could extend close to the Groot Hagelkraal and Koks River systems it was however unlikely to affect either of them.

Without the implementation of any mitigation measures, the cumulative implications of development of a single NPS at Bantamsklip were assessed as of at least medium negative significance from a wetland perspective.

E2.3 Thyspunt

Development at this site would, in the absence of mitigation measures, be associated with the greatest number, intensity and complexity of impacts to important wetland systems. The main impacts assessed include:

- Permanent loss and degradation of coastal seep wetlands as a result of dewatering / groundwater diversion, concentration of groundwater flows and proposed new roads;
- Some risks of impacts to the Langefonteinvlei as a result of possible draw-down effects: the likelihood of risk was however considered low, given the findings of Visser *et al*. (2011), namely that the Langefonteinvlei is perched above the groundwater table in its southern and western extents. Hence draw-down impacts would need to extend to the northern and eastern portions of Langefonteinvlei before they had an effect on wetland hydrology;
- Fragmentation, infilling and physical disturbance to duneslack wetlands in the Oyster Bay mobile dune system as well as to wetlands immediately north of the Oyster Bay dunefield, as a result of impacts associated with the proposed passage of transmission lines, roads and potential options for sediment transport across the dunes;
- Potential infilling and fragmentation of important valley bottom wetlands to allow the construction of access routes to the site, as well as laying of water pipelines;
- Degradation of depressional and other wetlands as a result of transporting excess spoil over the dunes to the HVY platform.

The above impacts are likely to result in significant degradation of a system that presently exists as a relatively unimpacted mosaic of terrestrial and wetland habitats, with high levels of interconnectivity and high overall biodiversity value, to which the wetland systems make a significant contribution. The cumulative impacts of the proposed development of a single NPS at the Thyspunt site without implementation of mitigation measures have been assessed as of high negative significance.

E3 Key mitigation measures proposed for each site

E3.1 Duynefontein

Avoidance mitigation of impacts to wetlands is considered feasible at this site. Mitigation measures focus on effective management of dust, stormwater and road construction processes, and the location of the NPS and its infrastructure in the least sensitive areas of the development envelopes. Within the EIA and HV corridors, retention of the mobile dunes as a viable system is recommended, to ensure maintenance of wetland functions within and to the north of the dunes. Wetlands on the Duynefontein site that lie outside of the “recommended development area” have, along with their terrestrial margins and interlinking corridors, been identified as “no development” areas.

E3.2 Bantamsklip

Essential mitigation measures for this site would require:

- Management of the site to the north of the R43 as a conservation area, with provision for the long-term conservation of the site (after the life span of the NPS)

In addition, the report noted the **desirability** of:

- Enlarging of the culverts at the Groot Hagelkraal crossing under the R43
- Adhering to certain development restrictions at Pearly Beach.

These recommendations affect areas outside of the direct control of Eskom and thus cannot be conditions of authorisation.

The cumulative impact of a NPS at this site, with mitigation, would be a positive impact of high significance, based on the opportunity entailed in the development for securing the long-term conservation of the wetland systems to the north of the R43.

E3.3 Thyspunt

Essential mitigation measures at Thyspunt would comprise the following:
- Recognition of various "no go" development areas and ecological setbacks – implementation of the latter would require that the proposed "recommended development area" on the site should be drawn towards the west, to accommodate the recommended (surface) Langefonteinvlei buffer;
- Management of the whole site, apart from the NPS footprint within the "recommended" development area as a formal conservation area;
- Purchase of all erven potentially crossed by the proposed eastern access road to the east of the Thyspunt site as far as the western boundary of The Links, and the management of the dunefields and wetlands thus acquired as a dedicated conservation area.

Mitigation against the risk of draw-down related impacts to the Langefonteinvlei include the incorporation of cutoff walls, semi-permeable membranes or other appropriate devices into dewatering design such that they effectively limit the radius of drawdown to the NPS excavation site itself, and prevent any risk of drawdown impacts affecting the Langefonteinvlei.

Mitigation measures against impacts to the coastal seeps centre on inclusion in the dewatering design of mechanisms that will allow the long-term redistribution and spread of diverted / dewatered groundwater back into the aquifer, such that it can feed the coastal seeps downstream, taking cognisance of projected increases in sea level that are likely to result in salinisation of groundwater levels just above present sea level.

Other recommended mitigation measures at this site would entail:
- The northern access road should not be used, and the western access road should be re-aligned northwards so as to avoid a number of coastal seeps;
- Access roads should allow for bridging of wetlands that are unavoidably crossed by the routes;
- Transmission lines should not include any maintenance / access roads across the mobile dunes, and provision should be made for access by helicopter or (potentially) quad bike only;
- Mitigation of impacts associated with the transport of sand across the mobile dunes is possible, if a conveyor system is utilised, but with substantial restrictions being imposed on construction / maintenance roads and sediment control.

Even with implementation of all of the mitigation measures outlined above, the cumulative outcome is still considered of net high negative significance, as a result of the residual impact to presently largely unimpacted wetlands (mainly associated with the Oyster Bay dunefield) across a substantial area, and the definite and unmitigable degradation of a limited area of currently unimpacted coastal seep wetlands.

However, offset mitigation is possible, and would involve conservation of areas that include both the Eastern Valley Bottom wetlands and the Oyster Bay dunefield itself, as far as the impacted area at the upstream boundary of The Links golf course. It is an important condition of this offset mitigation that all erven along the proposed eastern access road are secured before these are developed, thus securing a large expanse of wetland and dune system that would otherwise be permanently impacted or possibly destroyed by development. This does not mitigate against the loss and / or degradation of coastal seep wetlands, but the opportunity for large-scale active management and conservation of wetland ecosystems as a whole is considered to offset the loss of some of these important wetlands, while retaining the Langefonteinvlei and duneslack wetlands in an unimpacted condition. In the event that full mitigation as well as offset measures were implemented, the net impact to wetlands on the

Thyspunt site is likely to be positive, and a preferable scenario to the “no development” alternative.

This said, however, it is acknowledged that ideally, none of the wetlands within and associated with the Oyster Bay dunefield (i.e. in an area extending beyond the boundaries of the Eskom site itself) should form part of any development offset. In the event that a no development alternative was available to provide adequate funding opportunities for alien control, and provided that this alternative did not include piecemeal fragmentation of the area into multiple small developments, then such an option would clearly be preferred from an ecological perspective to any development of a nuclear power facility at this site.

ENVIRONMENTAL IMPACT ASSESSMENT FOR THE PROPOSED NUCLEAR POWER STATION ('NUCLEAR 1') AND ASSOCIATED INFRASTRUCTURE

CONTENTS

Section	Description		Page
E	**Executive Summary**		i
	E1	Introduction	i
	E2	Impacts associated with the proposed NPS	i
	E3	Key mitigation measures proposed for each site	ii
GLOSSARY 1			
ABBREVIATIONS			**4**
ACKNOWLEDGEMENTS			**5**
1	**INTRODUCTION**		**6**
	1.1	Background	6
	1.2	Terms of Reference	6
	1.3	Limitations and assumptions	8
	1.3.1	Limitations in the accuracy of wetland data collection, analysis and mapping	8
	1.3.2	Limitations in the scope of study included in this EIA	9
	1.3.3	Limitations in the level of updating of new information presented in this report	9
	1.4	Study Approach	11
	1.4.1	Timing of site assessments	11

1.4.2 Identification and mapping of wetlands 11
1.4.3 Collection of field data 11
1.4.4 Contextual assessment of aquatic invertebrate data 12
1.4.5 Classification of wetlands 12
1.4.6 Assessment of the sensitivity and conservation importance of wetlands 16

2 DESCRIPTION OF THE AFFECTED ENVIRONMENT 19

2.1 Duynefontein 19
2.1.1 Site overview and context 19
2.1.2 General description of wetland ecosystems associated with the site 19
2.1.3 Description of the characteristics of wetland types based on data from selected representative wetlands 24
Broad habitat descriptions 30
Water chemistry 31
Aquatic invertebrate fauna 32
Present ecological status of seasonally inundated wetlands 33
Links with other wetland types 34
B Characterisation and assessment of permanently saturated to inundated depressions 35
2.1.4 Wetland importance 37
2.1.5 Comments on wetland sensitivity 38
2.1.6 Description of wetland systems in the vicinity of the Duynefontein site: the Sout River 38
2.1.7 Implications of the baseline wetland assessment for future developments: 39

2.2 Bantamsklip 40
2.2.1 Site context and overview 40
2.2.2 Description of the Groot Hagelkraal wetlands 43
2.2.3 Aquatic invertebrate fauna 47
2.2.4 Assessment of Present Ecological Status (PES) of wetlands on the Bantamsklip site 50
2.2.5 Comments on wetland sensitivity 51

2.2.6 Assessment of Wetland Ecological Importance and Sensitivity (EIS) 51
2.2.7 Implications of the baseline wetland assessment for future developments: 52

2.3 Thyspunt 53
2.3.1 Site context and overview 53
2.3.2 Rainfall 56
2.3.3 Surface Hydrology 56
2.3.4 Geohydrological background 56
2.3.5 Classification of wetlands associated with the site 57
2.3.6 Wetland surface and groundwater links 59
2.3.7 Description of wetland physical, chemical and biological attributes 64
2.3.8 Assessment of Present Ecological Status (PES) of wetlands on and associated with the Thyspunt site 88
2.3.9 Comments on wetland sensitivity 90
2.3.10 Assessment of Wetland Ecological Importance and Sensitivity (EIS) 90
2.3.11 Implications of the baseline wetland assessment for future developments: 91

3 DESCRIPTION OF KEY ACTIVITIES ASSOCIATED WITH THE PROPOSED DEVELOPMENT 93

3.1 Overview 93

3.2 Description of layouts 93
3.2.1 Layouts 93
3.2.2 Setbacks and boundaries 94
3.2.3 Sewage disposal or treatment 94
3.2.4 Fresh water supply 94
3.2.5 Stormwater management 95
3.2.6 Dewatering 95
3.2.7 Disposal of spoil 95
3.2.8 Terrace Roads 96
3.2.9 Provision of a power supply during construction 96

3.3 Associated off-site development 96

3.3.1 Access roads 96
3.3.2 Staff housing 97

3.4 Site-Specific construction activities 97
3.4.1 Construction of the Nuclear Reactor and Turbine Building at Thyspunt 97
3.4.2 Linkage of transmission lines from the NPS to the proposed HV yard – Thyspunt Site 98

4 IMPACT IDENTIFICATION 104

4.1 Approach to identification of sources of impacts to wetland systems 104

4.2 Impacts associated with development of a nuclear power station at Duynefontein 105
4.2.1 Overview 105
4.2.2 Impacts associated with the construction phase 105
4.2.3 Impacts associated with the operational phase 111
4.2.4 Cumulative impacts of development of a single NPS at Duynefontein 111
4.2.5 Implications of climate change for wetlands on the Duynefontein site 111

4.3 Impacts associated with development of a nuclear power station at Bantamsklip 113
4.3.1 Overview 113
4.3.2 Impacts associated with the construction phase – Phase 1 113
4.3.3 Impacts associated with the operational phase 114
4.3.4 Implications of climate change for wetlands on the Bantamsklip site 119

4.4 Impacts associated with development of a Nuclear Power Station at Thyspunt 121
4.4.1 Overview 121
4.4.2 Impacts associated with the construction phase of a NPS 125
4.4.3 Impacts associated with the operational phase of the NPS 131
4.4.4 Impacts associated with sewage management options at Thyspunt 134

4.4.5 Impacts associated with different alternatives for fresh water supply on the site 135
4.4.6 Impacts of different options for linking transmission lines from the NPS to the proposed HV yard 135
4.4.7 Options for the removal of sand spoil from the NPS site 137
4.4.8 Impacts associated with different access road alternatives 138
4.4.9 Cumulative impacts associated with the NPS development at Thyspunt 147
4.4.10 The implications of climate change for wetlands at Thyspunt in a development context 147

5 RECOMMENDED MITIGATION MEASURES 151

5.1 Approach to setting and evaluating mitigation measures 151

5.2 Recommended mitigation measures: Duynefontein 152
5.2.1 General mitigation against loss or degradation of wetlands associated with site layout 152
5.2.2 Mitigation against construction phase impacts 153
5.2.3 Mitigation against operational phase impacts 153
5.2.4 Cumulative impacts of the construction and operational phases of the NPS and its associated activities, assuming mitigation 154
5.2.5 Monitoring and evaluation programme 156

5.3 Recommended mitigation for Bantamsklip 158
5.3.1 General mitigation against loss or degradation of wetlands associated with site layout 158
5.3.2 Mitigation against construction phase impacts 158
5.3.3 Mitigation against impacts associated with the operational phase 159
5.3.4 Recommended monitoring and evaluation programme 162

5.4 Recommended mitigation for Thyspunt 164
5.4.1 General mitigation against loss or degradation of wetlands associated with site layout 164
5.4.2 Mitigation against construction phase impacts 168
5.4.3 Mitigation against operational phase impacts associated with the NPS 172
5.4.4 Mitigation against impacts associated with sewage management 173

5.4.5 Mitigation against impacts associated with different alternatives for fresh water supply on the site 174
5.4.6 Mitigation against the impacts of different options for linking transmission lines from the NPS to the HV yard 175
5.4.7 Options for the removal of sand spoil from the NPS site 176
5.4.8 Mitigation against impacts associated with different access road alternatives 177
5.4.9 Mitigation against cumulative impacts of the construction and operational phases of the NPS and its associated activities addressed in this report 182
5.4.10 Recommended monitoring and evaluation programme 191

6 SUMMARY OF IMPACTS WITH AND WITHOUT MITIGATION 194

6.1 Description of the no-go alternative 194
6.1.1 General 194
6.1.2 Duynefontein site 194
6.1.3 Bantamsklip site 194
6.1.4 Thyspunt site 194

6.2 Summary of the outcomes of the impact assessments at each site 195
6.2.1 Duynefontein 195
6.2.2 Bantamsklip 195
6.2.3 Thyspunt 196

7 CONCLUSIONS 199

8 REFERENCES 202

APPENDICES 207

APPENDIX A 208

Revised classification of inland wetlands, after Ollis *et al*. (2008). 208

APPENDIX B 209

Environmental Importance and Sensitivity (EIS) protocol for wetlands 209

APPENDIX C 211

Protocols for the assessment of Present Ecological Status in wetlands: 211

Level 2 WET-Health assessment (Mc Farlane *et al*. 2008) 211

APPENDIX D **216**

Protocols for the assessment of Present Ecological Status in wetlands: PES adapted from DWAF (1999) 216

APPENDIX E **218**

APPENDIX F **227**

APPENDIX G **232**

FIGURES

Figure	Description	Page
Figure 1.1	Locations of the three alternative sites considered for development of a Nuclear Power Station	10
Figure 1.2	Basic structure of the (2009) National Wetland Classification System, showing how 'primary discriminators' are applied up to Level 4 to classify Hydrogeomorphic (HGM) Units, with 'secondary discriminators' applied at Level 5 to classify the tidal/hydrological regime, and 'descriptors' applied at Level 6 to categorise the characteristics of wetlands classified up to Level 5. Figure taken from SANBI (2009).	14
Figure 2.1	Site context of Duynefontein	22
Figure 2.2	Mapped extent of wetlands occurring on the Duynefontein site. Inset 1 shows the site location in relation to the other potential sites. Inset 2 shows an enlargement of the area defined by the blue box in the main figure.	23
Figure 2.3	Site context of Bantamsklip	41
Figure 2.4	Location of wetland systems identified on the Bantamsklip site.	42
Figure 2.4	Location of wetlands identified on the Bantamsklip site.	42
Figure 2.5	The Thyspunt site in the context of Oyster Bay and Cape St. Francis	54
Figure 2.6	Wetlands on the Thyspunt site and immediate surrounds, showing mapped wetland areas	55

Figure 2.7 Positions of cross-sectional views, shown in Figure 2.8, to depict the conceptual model of surface – groundwater interactions in the Langefonteinvlei. Figure after Visser et al. (2011). 62

Figure 2.8 Cross-sectional views depicting the conceptual model of surface – groundwater interactions in the Langefonteinvlei. Cross-sections from areas shown in Figure 2.7. Figure after Visser *et al.* (2011). 63

Figure 2.9 Comparison of major anions and cations at selected sample sites on and in the vicinity of the Thyspunt site. Data provided in Table 2.7. 66

Figure 2.10 Summary data showing relative abundance of aquatic invertebrate fauna in different habitats at the Thyspunt site. 71

Figure 3.1 Duynefontein site, showing the areas proposed for the location of different components of the NPS and its ancillary structures, as well as conceptual footprints for the terrace of a 4000 MW plant, a topsoil stockpile and a spoil stockpile. Figure courtesy Eskom. 99

Figure 3.2 Bantamsklip site, showing the areas proposed for the location of different components of the NPS and its ancillary structures, as well as conceptual footprints for the terrace of a 4000 MW plant, a topsoil stockpile and a spoil stockpile. Figure courtesy Eskom. 100

Figure 3.3 Thyspunt site, showing the areas proposed for the location of different components of the NPS and its ancillary structures, as well as conceptual footprints for the terrace of a 4000 MW plant, a topsoil stockpile and a spoil stockpile. Figure courtesy Eskom. 101

Figure 4.1A Determination of a least sensitive development area at Duynefontein, based on an overlay of mapped sensitivity areas for different specialist disciplines in the EIA process. Note that wetlands were not a major driver in the determination of a “recommended [development] site” at Duynefontein. Figure courtesy of GIBB. 108

Figure 4.1B Proposed corridors for the location of different components of an NPS at Duynefontein, showing development corridors and proposed infrastructure in the context of wetlands mapped at the site. Block on right hand corner indicates relative size of conceptual NPS footprint- footprint dimensions courtesy Eskom. “Recommended site” (or least sensitive development area) derived as per Figure 4.1A. 109

Figure 4.1C Modelled sensitivity of wetlands on the Duynefontein site to construction-associated groundwater drawdown. Model based on drawdown of the entire NPS footprint, and thus an exaggeration of extent of impact. Figure after Visser et al. (2011). 110

Figure 4.2A Determination of a least sensitive development area at Bantamsklip, based on an overlay of mapped sensitivity areas for different specialist disciplines in the EIA process. Figure courtesy Arcus Gibb. 115
Figure 4.2B Proposed corridors for the location of different components of an NPS at Bantamsklip, showing development corridors and proposed infrastructure in the context of wetlands mapped at the site. Block on right hand corner indicates relative size of conceptual NPS footprint- footprint dimensions courtesy Eskom. "Recommended site" (or least sensitive development area) derived as per Figure 4.2A. 116
Figure 4.3 Modelled radius of drawdown at the Bantamsklip site. Figure after Visser *et al* (2011). 117
Drawdown model based on dewatering of an area equivalent to one third of one NPS footprint. 117
Figure 4.4 Modelled increase in groundwater at Bantamsklip, assuming a 0.8m increase in sea level. Figure adapted from SRK (2009) data. Wetlands shown in blue. 120
Figure 4.5A Determination of a least sensitive development area at Thyspunt, based on an overlay of mapped sensitivity areas for different specialist disciplines in the EIA process. Figure courtesy of GIBB. 122
Figure 4.5B Proposed corridors for the location of different components of an NPS at Thyspunt, showing development corridors and proposed infrastructure in the context of wetlands mapped at the site. Block on right hand corner indicates relative size of conceptual NPS footprint- footprint dimensions courtesy Eskom. "Recommended site" (or least sensitive development area) derived as per Figure 4.5A. 123
Different components of a single NPS at Thyspunt, showing development corridors and proposed infrastructure in the context of wetlands mapped at the Thyspunt site. Significannce of areas marked "w", "x", "y" and "z" discussed in text (Section 4.4.9). Block on right hand corner indicates relative size of conceptual NPS footprint- footprint dimensions courtesy Eskom. 123
Figure 4.6 Detail of proposed corridors for the potential location of different components of a single NPS at Thyspunt, showing proposed development corridors, "recommended" development site and proposed infrastructure in the context of wetlands mapped at the Thyspunt site. 124
Areas marked "A", "B", "C", "D", "W and "Z" discussed in text (Section 4.4.9). 124
Figure 4.7 Modelled radius of drawdown at the Thyspunt site, assuming draw-down of eastern half of proposed NPS footprint. Figure after Visser et al. (2011). . Note that the extent of coastal seeps is not clear at this scale, and Figure 2.6 should be referred to, for a clearer indication of coastal seep extent. Wetlands shown in blue. 128

A Draw-down associated with the unmitigated implementation of a 4000 MW plant. 128

Figure 4.7 Modelled radius of drawdown at the Thyspunt site, assuming draw-down of eastern half of proposed NPS footprint. Figure after Visser *et al.* (2011). . Note that the extent of coastal seeps is not clear at this scale, and Figure 2.6 should be referred to, for a clearer indication of coastal seep extent. Wetlands shown in blue. 129

B Draw-down associated with the implementation of a 4000 MW plant, with mitigation in the form of a partial cut-off wall (shown as a black line) 129

Figure 4.8 Modelled increase in groundwater at Thyspunt, assuming a 0.8m increase in sea level. Figure adapted from SRK (2009) data. Note that the extent of coastal seeps is not clear at this scale, and Figure 2.6 should be referred to, for a clearer indication of coastal seep extent. Wetlands shown in blue. 150

Figure 5.1 Proposed development corridors, "recommended" development site and proposed infrastructure in the context of wetlands mapped at the Thyspunt site, showing recommended setback areas from different wetland types. Buffers as recommended in Section 5. 4.1. 166

Figure G1 Locations of spot site assessments and/or auger positions on the main Oyster Bay dunefield, in September 2009. 234

Figure G2 Logged borehole data from two sites in the Oyster Bay dunefield 234

TABLES

Table	Description	Page
Table 1.1	Classification structure for Inland Systems, up to Level 4 (SANBI (2009)	15
Table 1.2	Description of the Present Ecological State categories of WET-Health	18
Table 1.3	Interpretation of PES score, using the DWAF (1999) methodology.	18
Table 2.1	Water quality in sampled wetland sites at Duynefontein	24
Table 2.2	Summary of ranges of phosphorus and/or nitrogen-based nutrients associated with different trophic conditions in aquatic ecosystems	25
Table 2.3	Invertebrate taxa from sampled seasonal wetland sites at the Duynefontein site	26
Table 2.4	Water quality in sampled wetland sites at Bantamsklip, all from the Groot Hagelkraal wetland system	43
Table 2.5	Invertebrate taxa from wetland sites at Bantamsklip	48
Table 2.6	Water quality in sampled wetland sites at Thyspunt	65
Table 2.7	List of taxa from seven wetland samples collected at Thyspunt	67
Table 2.8	Summary information regarding major wetland types identified in Section 2.3.5	72
Table 5.1	Assessment of impacts to wetlands as a result of development of a nuclear power station at Duynefontein	155
Table 5.2	Recommended wetland monitoring programme at Duynefontein	157

Table 5.3	Assessment of impacts to wetlands as a result of development of a nuclear power station at Bantamsklip	155
Table 5.4	Recommended wetland monitoring programme at Bantamsklip	157
Table 5.5	Assessment of impacts to wetlands as a result of development of a nuclear power station at Thyspunt	155
Table 5.6	Recommended wetland monitoring programme at Thyspunt	192
Table G1	Observations from the September 2009 field survey of duneslack wetlands (September 2009)	233

GLOSSARY

Aquifer - A geological formation, which has structures or textures that hold water or permit appreciable water movement [from the National Water Act, 1998 (Act No. 36 of 1998)]. Also defined as the saturated zone of a geological formation beneath the water table, capable of supplying economic and usable volumes of groundwater to borehole(s) and / or springs (SRK 2009)

Aquifer system - A heterogeneous body of interlayered permeable and less permeable material that act as a water-yielding hydraulic unit covering a region. (SRK 2009)

Aquitard - A geological formation, with low permeability that retards and restricts the vertical and / or horizontal movement of groundwater, but does not prevent the movement of groundwater (SRK 2009).

Baseflow - The sustained low flow in a river during dry and / or fair weather conditions, but not necessarily all contributed by groundwater; includes contributions from delayed interflow and groundwater discharge (SRK 2009)

Brackish (as relates to salinity/conductivity) – for Inland Systems, with salinity of 2.0 –12.0 g/l (or electrical conductivity ca. 300 – 1 800 mS/m) (SANBI 2009)

Channelled valley-bottom wetland – a mostly flat wetland area on a valley floor (see valley floor) that is dissected by and typically elevated above a well defined stream channel (see channel). Dominant water inputs to these areas are typically from the channel (when it overtops or from sub-surface discharge) and from adjacent valley-side slopes (SANBI 2009)

Classification (of wetlands) - The grouping of similar types of wetlands with homogeneous natural attributes (e.g. hydrogeomorphic or morphological characteristics) into categories and sub-categories, typically for the purpose of wetland inventory. This is different from the meaning used by DWAF and NDA, where classification (of rivers, wetlands, estuaries etc.) is a grading system that uses various categories to describe the condition of a water resource, or part thereof (DWAF 2004)

Clay (substratum type) – a very fine-textured sedimentary deposit consisting of naturally-occurring inorganic soil particles <0.002 mm in diameter (SANBI 2009)

Delineation (of a wetland) - The determination of the boundary of a wetland (the outer edge of the temporary aquatic zone that marks the boundary between the wetland and adjacent terrestrial areas) based on soil, vegetation and/or hydrological indicators (see definition of a wetland) (Day and Malan 2009)

Depression – a landform with closed elevation contours that increases in depth from the perimeter to a central area of greatest depth, and within which water typically accumulates. Dominant water sources are precipitation, ground water discharge, interflow and (diffuse or concentrated) overland flow. Dominant hydrodynamics are (primarily seasonal) vertical fluctuations. Depressions may be flat-bottomed (in which case they are often referred to as 'pans') or round-bottomed (in which case they are often referred to as 'basins'), and may have any combination of inlets and outlets or lack them completely (SANBI 2009)

Discharge area - An area in which subsurface water, including water in the unsaturated and saturated zones, is discharged at the land surface (SRK 2009)

Drawdown - The lowering of the water table in and around a pumping borehole. It is measured as the difference between pumping groundwater level and the original or rest groundwater level (SRK 2009)

Electrical conductivity - A measurement of the ease with which water conducts electricity. Distilled water conducts electricity poorly, while sea water, with its very high salt content, is a very good conductor of electricity

Eskom Site – this term "refers to the owner-controlled boundary of each assessed site, and not to the proposed development envelope within this site

Fresh (as relates to salinity/conductivity) – for Marine and Estuarine Systems, with a salinity of < 0.5 g/l; for Inland Systems, with a salinity of < 2.0 g/l (or electrical conductivity < ca. 300 mS/m) (SANBI 2009)

Geohydrology - The study of the properties, circulation and distribution of groundwater, in practise used interchangeably with hydrogeology; but in theory hydrogeology is the study of geology from the perspective of its role and influence in hydrology, while geohydrology is the study of hydrology from the perspective of the influence on geology (SRK 2009)

Groundwater flow - The movement of water through openings and pore spaces in rocks below the water table, i.e. in the saturated zone. Groundwater naturally drains from higher lying areas to low lying areas such as rivers, lakes and the oceans. The rate of flow depends on the slope (gradient) of the water table and the transmissivity of the geological formations (SRK 2009)

Groundwater - Water found in the subsurface in the saturated zone below the water table or piezometric surface, i.e. the water table marks the upper surface of groundwater systems (SRK 2009)

Head cut - The upper-most entrance into an erosion gully. The point where the headward extension of a gully is actively eroding into undisturbed soil. (Day and Malan 2009)

Hillslope seep – a wetland area located on (gently to steeply) sloping land, which is dominated by the colluvial (i.e. gravity-driven), unidirectional movement of material down-slope. Water inputs are primarily from subsurface flow that enters the wetland from an up-slope direction (SANBI 2009)

Hydro-geomorphic (HGM) type - Classification of wetlands or portions of wetlands on the basis of their hydrological and geomorphological characteristics. It encompasses three key elements of (1) geomorphic setting (i.e. the landform, its position in the landscape and how it evolved, e.g. through the deposition of river-borne sediment); (2) water source (i.e. where does the water come from that is maintaining the wetland?) of which there are usually several sources including precipitation, groundwater flow and streamflow, but their relative contributions will vary amongst wetlands; and (3) hydrodynamics, which refers to how water moves through the wetland (Day and Malan 2009)

In-channel dam – a waterbody that has been created by the unnatural accumulation of water behind an artificial barrier constructed across a channel. (SANBI 2009)

Infilling - Dumping of soil or solid waste onto the wetland surface. Infilling generally has a very high and permanent impact on wetland functioning and is similar to drainage in that the upper soil layers are rendered less wet, usually so much so that the area no longer functions as a wetland (Day and Malan 2009)

Intertidal – the area between mean spring low tide and mean spring high tide, where the substratum is alternately flooded and exposed by tides (i.e. periodically submerged) (SANBI 2009)

Non-permanent (seasonal/temporary) – with wet conditions (i.e. surface water or saturated soils) present at certain times but not continuously through the year. (SANBI 2009)

Off-channel dam – an artificial depression that has been excavated for the storage of water (includes “irrigation ponds”, “farm dams”). Water accumulates within these ‘dams’ through surface runoff, precipitation, and the diversion or pumping of water from other locations (such as from rivers via canals/pipelines, or from groundwater via wind pumps) (SANBI 2009)

Perched water table - Localised, unconfined groundwater separated from the underlying main body of groundwater by an unsaturated zone, i.e. the local water table is not in hydraulic continuity with the regional groundwater system (SRK 2009)

Perennial – flows or holds water continuously throughout the year (SANBI 2009)

Permanent – with wet conditions (i.e. surface water or saturated soils) present throughout the year (SANBI 2009)

Permanently inundated – with surface water present throughout the year (SANBI 2009).

Permanently open (as relates to an estuarine system) – an estuarine system which has a mouth that is always open to the sea (usually, but not always, fed by a perennial river) (SANBI 2009)

Permanently saturated – of wetland soils, where all the spaces between the soil particles are permanently filled with water. This corresponds to the “permanent (inner) zone” of a wetland, according to the terminology used in the DWAF (2005) wetland delineation manual (SANBI 2009)

Quaternary catchment - A fourth order catchment in a hierarchal classification system in which a primary catchment is the major unit (SRK 2009)

Red Data species - All those species included in the categories of endangered, vulnerable or rare, as defined by the International Union for the Conservation of Nature and Natural Resources (Day and Malan 2009)

Resilience - The ability of a system to maintain its functionality when it is subject to perturbations or shocks (e.g. a major drought), or to maintain the elements needed to renew or reorganize if a large perturbation radically alters structure and function (Day and Malan 2009)

Runoff - All surface and subsurface flow from a catchment, but in practice refers to the flow in a river, i.e. excludes groundwater not discharged into a river (SRK 2009)

Saline (as relates to salinity/conductivity) – for Inland Systems, with salinity 12.0 – 40.0 g/l (or electrical conductivity ca. 1 800 – 6 000 mS/m) (SANBI 2009)

Saline intrusion - Replacement of freshwater by saline water in an aquifer, usually as a result of groundwater abstraction (SRK 2009)

Saturated (waterlogged) – of soil, a condition in which the spaces between the soil particles are filled with water but surface water is not present (SANBI 2009)

Seasonal – of perenniality, with water present for extended periods during the wet season but not during the rest of the year (SANBI 2009)

Seasonally inundated – of soils, with surface water present for extended periods (usually more than three to four weeks duration) during the wet season but drying up annually, either to complete dryness or to saturation during the dry season (SANBI 2009)

Seasonally saturated – of wetland soils, with all the spaces between the particles filled with water for extended periods (3 – 10 months of the year), usually during the wet season, but dry for the rest of the year (during the dry season). This corresponds to the “seasonal zone” of a wetland, according to the terminology used in the DWAF (2005) wetland delineation manual (SANBI 2009)

Spring - A point where groundwater emerges, usually as a result of topographical, lithological and / or structural control (SRK 2009)

Unchannelled valley-bottom wetland – a mostly flat valley-bottom wetland area without a well-defined stream channel running through it, characterised by an absence of distinct channel banks and the prevalence of diffuse flows, even during and after rainfall events. Water inputs are typically from an upstream channel, as the flow becomes dispersed, and fro m adjacent slopes (if present) (SANBI 2009)

Unconfined aquifer - An aquifer with no confining layer between the water table and the ground surface where the water table is free to fluctuate. (SRK 2009)

Water table - The upper surface of the saturated zone of an unconfined aquifer at which pore pressure is at atmospheric pressure, the depth to which may fluctuate seasonally (SRK 2009)

Wetland - An area “of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tides does not exceed ten meters. Wetlands are areas where water is the primary factor controlling the environment and, therefore, wetlands develop in areas where soils are saturated or inundated with water for varying lengths of time and at different frequencies” (National Wetland Classification definition after SANBI 2009)

ABBREVIATIONS

CMA:	Cape Town Metropolitan Area
CoCT:	City of Cape Town
DO	Dissolved oxygen
DOPER	Dissolved oxygen (percentage concentration)
DWAF:	Department of Water Affairs and Forestry
DEA:	Department of Environmental Affairs
EC:	Electrical conductivity
EIA:	Environmental Impact Assessment
EMP:	Environmental Management Programme
FCG	The Freshwater Consulting Group / Freshwater Consulting cc
GPS:	Global Positioning System
ha:	hectares
HV:	High voltage
HVY:	High Voltage Yard
IPCC	Intergovernmental Panel on Climate Change
magl:	metres above ground level
mamsl:	metres above mean sea level
MAR:	Mean annual runoff
mg/L:	milligrams per litre
mmol:	Millimole
mol:	Mole
mS/m:	milli-Siemens per metre
NWCS	National Wetland Classification System
NPS	Nuclear Power Station
NS	Nuclear Site
KNPS	Koeberg Nuclear Power Station
PBMR DPP:	Pebble Bed Modular Reactor Demonstration Power Plant
Rhodes	Rhodes University
SRK:	SRK Consulting Engineers and Scientists (South Africa) (Pty) Ltd
TMG:	Table Mountain Group
UCT	University of Cape Town
WCS:	Wetland Consulting Services
WRC:	Water Research Commission
WWTW:	Wastewater treatment works

ACKNOWLEDGEMENTS

Input from the following individuals / specialists / organizations into this report is gratefully acknowledged:

Dr Mike Picker (University of Cape Town) provided useful input into site evaluations;

Mr Gert Greeff (Eskom – Estates Manager) provided invaluable background information regarding the sites and their history and assisted on site;

Mr Henni de Beer (Eskom – Environmental Manager - Thyspunt) assisted with accessing portions of the site by quad bike and provided useful input into discussions;

Liaison with the following specialists engaged in this project also took place:

- Mr Peter Rosewarne (SRK Consulting) – groundwater
- Mr Bruce Engelsman (SRK Consulting) – groundwater and hydrology
- Mr Johan Du Plooy (SRK Consulting) – groundwater and hydrology
- Mr Matt Braune (SRK Consulting) – stormwater management
- Mr Barrie Low (COASTEC) (vegetation)
- Mr Werner Illenberger (dune geomorphologist)
- Mr James Harrison (fauna)
- Mr Marius Burger (fauna)

Internal review of this report was provided by Ms Geordie Ractliffe (FCG);

Mr Ian Wilson (Spatial Modelling Solutions) assisted with GIS covers and figures;

Mr Pete Illigner, Professor Fred Ellery and Professor Richard Cowling are thanked for useful discussions around the functioning of the Thyspunt wetlands;

Mrs Caryl Logie (local botanist – Cape St. Francis) is thanked for useful discussions in the field at Thyspunt;

Dup & Ethel Papenfus, for their willing assistance at the Thyspunt site and their warm hospitality; Dr Denise Schael (Nelson Mandela Metropolitan University) identified wetland invertebrates, provided useful background information on habitat ranges for key species and assisted with PRIMER analyses.

1 INTRODUCTION

1.1 Background

Eskom Holdings (Ltd) has proposed the construction of a 4000 MW Nuclear Power Station (NPS) on one of five alternative sites, located in the Northern, Eastern and Western Cape Provinces of South Africa. Arcus GIBB (Pty) Ltd (Arcus Gibb) were appointed by Eskom Holdings (Pty) Ltd (referred to hereafter as Eskom) to undertake the Environmental Impact Assessment (EIA) for the proposed NPS and its associated infrastructure within each site. Since several of the sites include or are associated with wetland systems, the Freshwater Consulting Group (FCG) was appointed by Arcus GIBB to provide specialist input into the EIA process.

Input by various specialists and organisations into the Scoping Phase of the project resulted in the exclusion of the two Northern Cape sites from further investigation during the EIA phase. The two sites were excluded on the basis of the desire to achieve optimal utilisation of infrastructure, avoidance of unnecessary environmental impacts and the need to provide power within Eskom's required time frames (Arcus GIBB 2008). The three remaining sites included in the detailed EIA assessment comprise Duynefontein (Western Cape), Bantamsklip (Western Cape) and Thyspunt (Eastern Cape) (Figure 1).

The present document comprises the 2nd draft of the specialist wetland report for the draft Environmental Impact Report (EIR). This follows on from the Scoping Phase report, which included Scoping Level input by FCG as reported in Day (2007), and the first draft specialist report (Day 2010), which was submitted for public comment in 2010.

1.2 Terms of Reference

FCG's proposals for the EIA phase of the project were that the study should include at least the following activities, which were then incorporated into the study Terms of Reference:

- Broad-scale identification and assessment of sensitivity, ecological function and conservation importance of any freshwater ecosystems on or associated with the alternative NPS locations, and field-based GIS mapping of their extent. The terms of reference were amended by Arcus Gibb in the case of the Bantamsklip site, for which wetland extent was mapped as a desktop exercise only. Although this meant that the wetland delineation at this site would be inaccurate, the affected wetlands were considered too far from the proposed zone of impact for such inaccuracies to affect the outcome of the EIA assessment.

- Qualitative assessments of wetland macroinvertebrate fauna (identified to as high a taxonomic level as possible) within representatives of each wetland type, with comments on plant community structure and wetland function.
- Assessment of the potential impacts on wetlands associated with the following infrastructure at each of the proposed NPS sites:
    - a desalinisation plant;
    - on-site administrative and other associated activities; and
    - roads and infrastructure on site, including a 400kv power line between the NPS and the High Voltage Yard at the Thyspunt site; and
- Provision of appropriate and practical mitigation measures that could reduce significant negative impacts of the proposed developments on freshwater ecosystems.

In addition to the afore-mentioned activities, FCG's Terms of Reference were expanded (July 2008 and July 2009) to include the following items:

- An assessment of alternative proposed access roads to the Thyspunt site, including:
    - Identification and visual assessment of wetlands along or potentially affected by the proposed routes;
    - Identification of potential constraints to road construction or route design in terms of likely impacts to identified freshwater ecosystems;
    - Identification of opportunities for wetland conservation in terms of road construction or route design;
    - Input into an iterative process of the engineering design of the road route and alignment; and
    - Inclusion of these assessments into the overall wetland EIA report for this project
- Assessment of the potential impacts of specified alternatives for the temporary storage and/or disposal of spoil at all three sites.

FCG was also requested by Arcus Gibb to comment on the implications of climate change for wetland ecosystems, and the effect that this might have on the significance of the impacts identified as likely to be associated with development of a NPS at each site.

The 1st draft specialist report (Day 2010) was revised in November 2010, to include a new assessment methodology, supplied to all EIA specialists by Arcus Gibb, as well as to make minor additions to the report, as a result of input from Interested and Affected Parties (I&APs) during the most recent comments period. These additions are included in Sections 3 and 4, and focus on more detailed descriptions of both the No Development Alternative at Thyspunt, and the impact offset measures, also recommended at Thyspunt.

The second draft specialist report has also taken cognisance of the outcomes of the following additional sources of information:

- The first annual site monitoring report (Visser *et al*. 2011), which presents the findings of a year of intensive groundwater and surface water monitoring at each of the three proposed NPS sites, and has thus allowed higher levels of confidence to be accorded to predictions of the impacts of proposed activities associated with the development of a NPS, on wetlands at each of the three alternative sites;
- The addendum report to the specialist Geomorphology EIA (Illenberger 2010), which addresses the issue of alleged debris flows at the Thyspunt site.

1.3 Limitations and assumptions

1.3.1 Limitations in the accuracy of wetland data collection, analysis and mapping

FCG's budget allowed for between two and six days per site for data collection and wetland mapping. Considerably more time was in fact spent on these tasks than allowed for in the budget. Given the size of the study areas, however, and the diversity of landforms within each site, this remains a limitation on the number of wetlands that could be sampled, as well as on the accuracy to which wetland extent could be mapped, and the data are unlikely to reflect the full spatial and temporal variation in aquatic ecosystem communities and water chemistry. Despite this, FCG is confident that a representative number of localities were sampled at each of the three sites, both for water chemistry and aquatic invertebrates, to allow adequate qualitative descriptions of wetland types.

In addition to budget constraints on time, the accuracy of mapping of wetland extent was also limited, in the case of the **Thyspunt** wetlands, by a number of other factors:

- Extensive alien vegetation made access to portions of the wetlands impossible, preventing collection of GPS waypoints to demarcate wetland edges in some areas of the site;
- Extensive alien vegetation cover on aerial photographs obscured wetland edges, again making desk-based delineation inaccurate in places;
- Alien vegetation is often associated with desiccation of wetland soils, a reduction in the presence of surface water and loss of characteristic wetland plant species, potentially resulting in an under-estimation of their natural extent in highly invaded areas. In the case of Thyspunt, such areas lie mainly to the east of the site. Removal of alien vegetation in the future is likely to result in expansion of some wetland areas, as a result of local raising of the water table; and
- The positions of individual, seasonally inundated duneslack wetlands on the Thyspunt dunefields are likely to change over time, and the wetland layer generated during the present study should be seen as a snap-shot representation of present wetland extent, rather than being regarded as a definitive wetland layer.

The mapped wetlands on the Thyspunt site should thus be regarded as broadly accurate spatial representations of wetland extent, but by no means constituting formally delineated systems (as per the Wetland Delineation Methodology of DWAF 2005). They are, however, considered adequate for the purposes of this EIA.

Mapping of wetlands on the **Bantamsklip** site took place at a desktop level only, based on aerial photography. Although the broad extent of wetlands on the site has been captured with a high level of confidence, the exact extent of wetland areas is unlikely to be accurately mapped. Where possible, wetland mapping has also drawn on existing wetland delineations (e.g. Cole *et al.* (2000)) to improve the resolution of mapped areas. Further field-based mapping of these wetlands was not considered a high priority at this site, given that the mapped wetlands lay well away from the area to be impacted by the proposed Nuclear 1 activities and development footprints.

Identification of aquatic invertebrates was carried out to the highest taxonomic level possible, based on available information and invertebrate keys. To date, there has however been limited collection of such data in the Western Cape, and indeed in South Africa as a whole, making comparison of faunal communities difficult, and thus limiting the extent to which interpretations of the relative importance of different wetlands can be quantified. Furthermore, species-level identification keys are not yet available for some of the South African aquatic invertebrate taxa (e.g. coleopteran (beetle) taxa) and although identifications have relied on the best available keys at present, revisions of these species lists may be necessary in the future as understanding of wetland invertebrate faunal diversity improves.

The collection of aquatic invertebrate data was limited to areas with adequate amounts of standing water at the time of sampling. Invertebrates were not collected from the artificial infiltration ponds in the north of the Duynefontein site. Data do exist for these ponds (Day 2005), and additional samples were not considered to be likely to contribute to any improved understanding of these wetlands.

1.3.2 Limitations in the scope of study included in this EIA

While the practical difficulties associated with undertaking an EIA that includes all aspects of a NPS, both on and off-site, are recognised, the separation from this study of the assessment of certain infrastructure components such as the routing of transmission lines from each site could potentially result in a net under-estimation of the cumulative impact of the proposed NPS on freshwater ecosystems and an over-estimation of potential positive impacts. This aspect was considered particularly relevant to the Bantamsklip site, where there is some argument for assigning aspects of the proposed development a positive impact assessment rating. Liaison with the botanical specialist engaged in the Bantamsklip transmission site EIA (Mr Nick Helme) was however carried out, to limit the risk of under-estimating cumulative impacts associated with the project.

The present EIA specifically excluded assessment of staff accommodation associated with the proposed Nuclear 1 developments at the three potential sites.

The specific implications of an accidental spill or leak of radioactive nuclear waste on wetlands was not assessed in this report – this lies outside of the expertise of this specialist.

1.3.3 Limitations in the level of updating of new information presented in this report

This report has been updated to reflect the findings of new research, presented in Visser et al. (2011). The latter study included updated Present Ecological Status, water and sediment chemistry, wetland mapping and geohydrological assessments of the three proposed NPS sites. The present report has not been revised to include all of these data, which can be sourced in Visser et al (2011), and only the conclusions of the latter have been incorporated here.

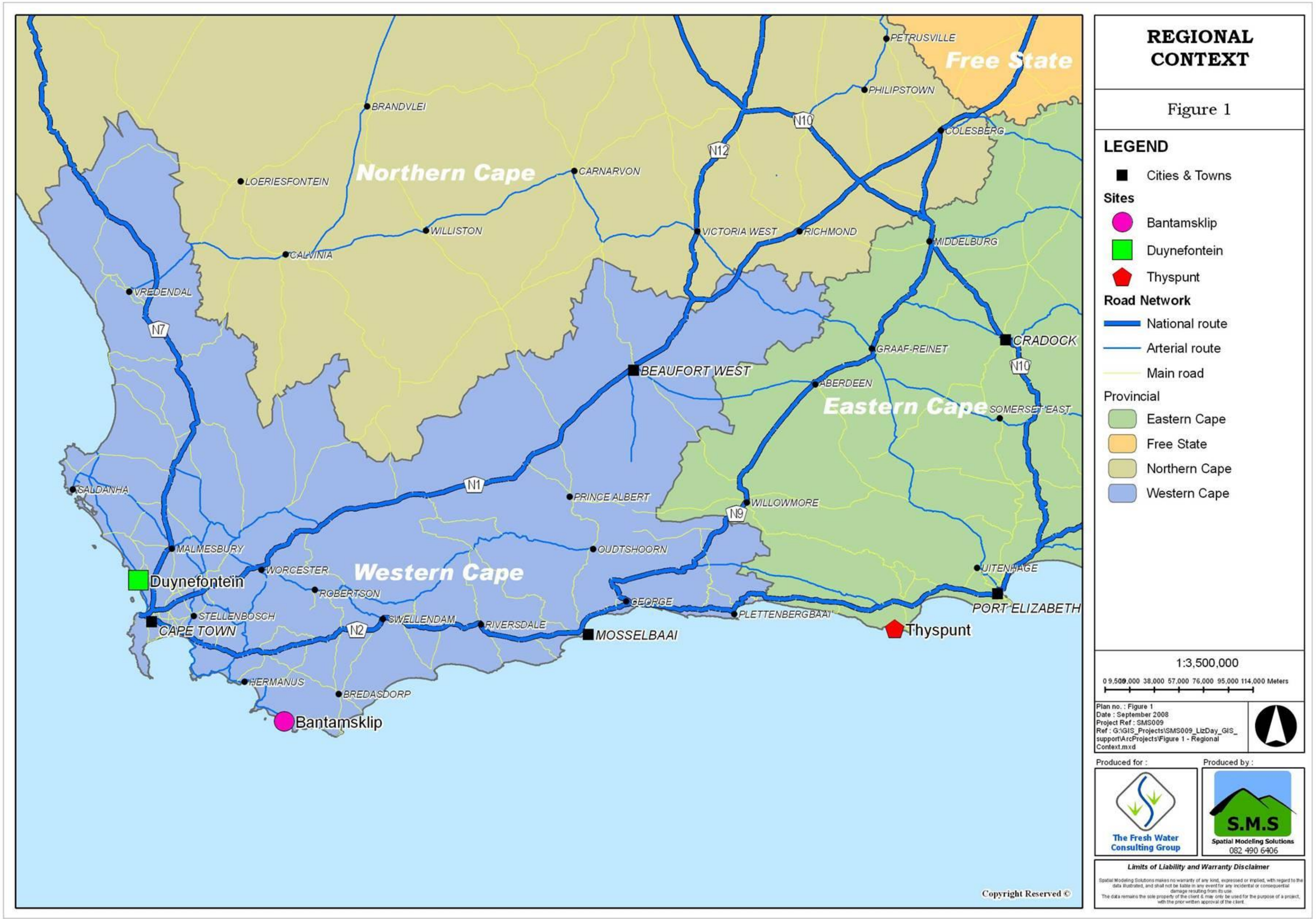


Figure 1.1 Locations of the three alternative sites considered for development of a Nuclear Power Station

1.4 Study Approach

1.4.1 Timing of site assessments

Site assessments were carried out during the following time periods:

Duynefontein site:
- July 2007;
- October 2007;
- January 2008;
- August 2008;
- April 2009; and
- October 2009

Bantamsklip site:
- July 2007;
- October 2007; and
- August 2008

Thyspunt site:
- July 2007;
- October 2007;
- July 2008;
- August 2008 (access road assessment); and
- September 2009.

1.4.2 Identification and mapping of wetlands

Identification and mapping of wetlands within the alternative sites was based on a combination of the following activities:

- A desk-top assessment of digital aerial photographs and available GIS covers for the study area to identify likely wetland areas;
- Accessing existing spatial wetland data for the sites, including that provided by related projects such as the assessment of the [1]proposed PBMR DPP at Duynefontein (Day 2007);
- Ground truthing of data, within the limitations outlined in Section 1.3.1, by driving, walking and, in the case of the Thyspunt dune areas, by quad-biking the area, to confirm the existence of mapped wetland areas, to provide spot GPS data for their locations; and
- Refinement of existing GIS wetland covers to include new information gathered during this exercise.

1.4.3 Collection of field data

The following field data were collected from selected representative wetland sites on each of the proposed NPS sites, to provide input into the baseline descriptions of wetlands on the sites:

[1] Note that proposals to construct a demonstration Pebble Bed Modular Reactor (PBMR) at Duynefontein have subsequently been withdrawn

- *In situ* physical data – pH, dissolved oxygen (DO), percentage dissolved oxygen saturation (DOPER), electrical conductivity (EC) and temperature;
- Aquatic and semi-aquatic invertebrate fauna – these were sweep-sampled with an 80µm plankton net and identified to as close to species level as available taxonomic information allowed (see Section 1.3.1);
- Water chemistry data – samples were analysed at the CSIR marine laboratory (Stellenbosch) for major nutrients (PO_4-P, Total P, NH_4-N, (NO_3+NO_2)-N) and at the CSIR freshwater laboratory (Stellenbosch) for major anions and cations (Ca, Mg, Na, K, Cl, SO_4); and
- Augering of wetland soils – wetlands were augured with a hand augur, and notes taken regarding broad soil characteristics; depth to water table and the presence or absence of near-surface material likely to act as a local aquitard.

1.4.4 Contextual assessment of aquatic invertebrate data

Data regarding the community composition of wetland invertebrate fauna is limited in South Africa, despite the fact that it is widely cited that this component can include regionally or even locally endemic taxa and make a significant contribution to the biodiversity importance of many wetlands. During the course of the present study, FCG collaborated in a four year Water Research Commission (WRC) Programme aimed at developing methodologies for the assessment of wetland condition and integrity (the Wetland Health and Integrity Programme). One component of this project was the collection and analysis of invertebrate data from over 145 wetlands, all classified in terms of SANBI (2009) at Level 4A as "depressions" (see Section 1.4.5) (Bird 2009). The resultant database was available by the end of the present study, and forms the best currently available set of regional data against which to compare invertebrate data collected at the individual sites assessed here. The latter were thus included in the database, and multi-variate analyses, using the computer analytical package PRIMER (Clarke and Warwick 1994) were run on the data. These results have been presented separately in Appendix E, and are drawn on in discussions of wetland taxa, where relevant. The strength of the analyses is still limited by the overall paucity of data on wetland invertebrate communities, however, with little data available for comparison for sites on the south coast, and all of the data available from the WRC database being sourced from Western Cape systems.

1.4.5 Classification of wetlands

The revised National Wetland Classification (SANBI 2009) was used as the basis for classifying different wetland types associated with the three study areas, using the following definition of wetlands taken directly from that of the National Wetland Classification as a starting point:

> Wetlands are … "*areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tides does not exceed ten meters. Wetlands are areas where water is the primary factor controlling the environment and, therefore, wetlands develop in areas where soils are saturated or inundated with water for varying lengths of time and at different frequencies*".

Using this definition, the National Wetland Classification System (NWCS) divides wetlands into three system types, namely Marine, Estuarine and Inland systems. In terms of this definition, rivers are one of a number of different wetland types.

The present study addresses only Inland wetland systems. In this regard it is noted that a number of coastal seeps have been identified at the Thyspunt site (see Section 2.3). The seaward section of these seeps could in theory be classified as estuarine. However, given their small size, the extremely short distance within which salinity gradients occur between the end of the clearly defined freshwater seep area and the sea (usually <10m) and the absence of any defined estuarine fauna or flora in these areas, the coastal seeps have been treated in this study as inland systems.

The NWCS has a six-tiered structure, with four spatially-nested primary levels that are applied in a hierarchical manner to distinguish between different wetland types on the basis of “primary discriminators” (that is, criteria that distinguish between different categories at each level of the hierarchy) (SANBI 2009). The first of the four spatially nested levels is the Systems Level, outlined above, and this level progresses through to Level 4, at the finest level of spatial detail, namely “Hydrogeomorphic (HGM) Units” (SANBI 2009).

The HGM Unit (Level 4) is the focal point of the classification system, with the higher levels providing the broad biogeographical context for grouping functional wetland units at the HGM level and the lower levels providing a more detailed description of the characteristics of a particular HGM Unit. The HGM Unit and the hydrological regime of an Inland System together constitute a “Functional Unit” (SANBI 2009).

Figure 1.2 (after SANBI 2009) illustrates the basic structure of the classification system, while Table 1.1 illustrates in more detail the first four tiers of the range of options for wetland descriptors at each level.

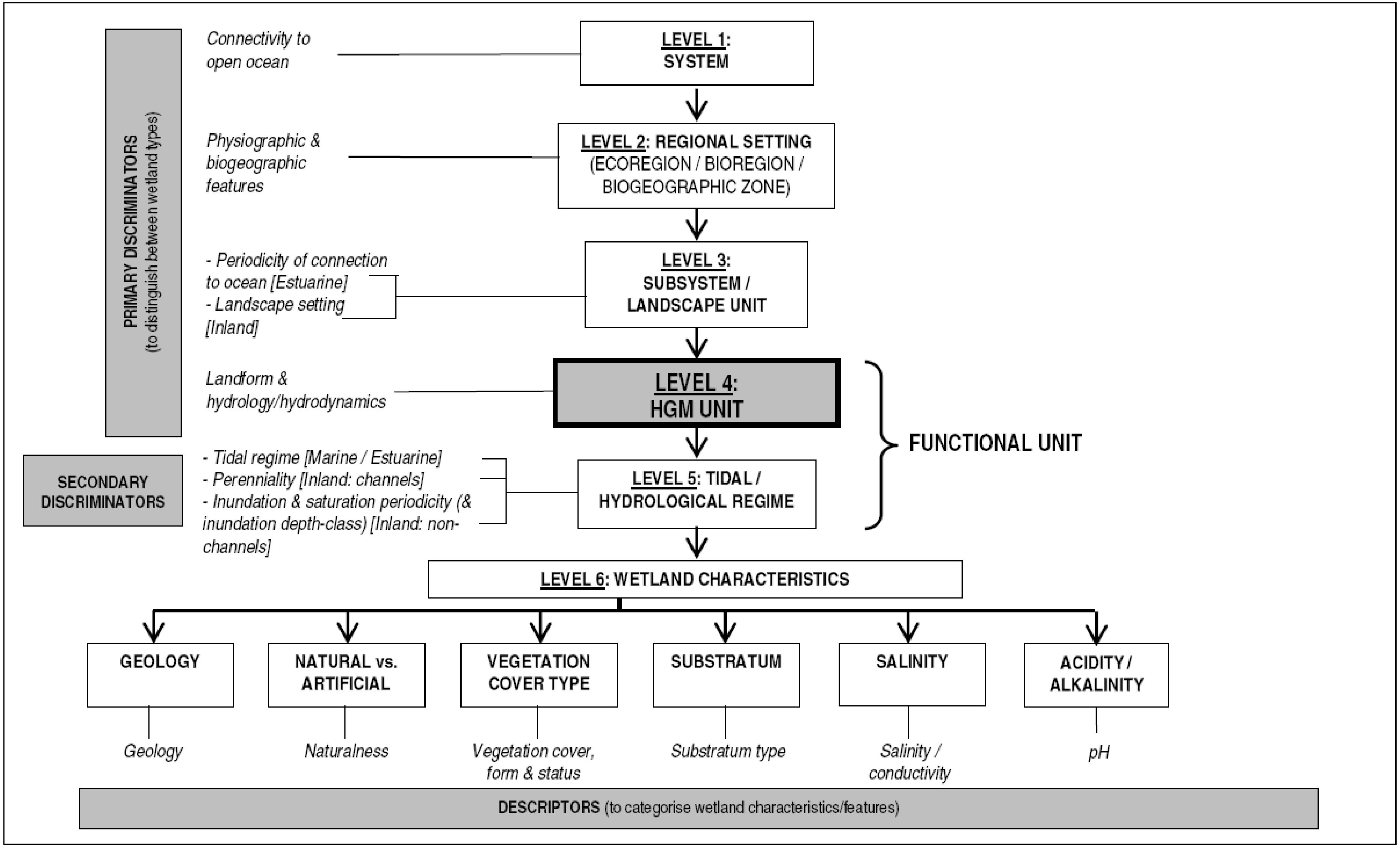


Figure 1.2 **Basic structure of the (2009) National Wetland Classification System, showing how 'primary discriminators' are applied up to Level 4 to classify Hydrogeomorphic (HGM) Units, with 'secondary discriminators' applied at Level 5 to classify the tidal/hydrological regime, and 'descriptors' applied at Level 6 to categorise the characteristics of wetlands classified up to Level 5. Figure taken from SANBI (2009).**

Table 1.1 Classification structure for Inland Systems, up to Level 4 (SANBI (2009)

LEVEL 1: SYSTEM	LEVEL 2: REGIONAL SETTING	LEVEL 3: LANDSCAPE UNIT	LEVEL 4: HYDROGEOMORPHIC (HGM) UNIT			
CONNECTIVITY TO OPEN OCEAN	*ECOREGION*	*LANDSCAPE SETTING*	*HGM TYPE*	*LONGITUDINAL ZONATION / LANDFORM*	*DRAINAGE - OUTFLOW**	*DRAINAGE - INFLOW**
			A	B	C	D
INLAND	DWAF Level I Ecoregions	SLOPE	Channel (river)	Mountain headwater stream	[not applicable]	[not applicable]
				Mountain stream	[not applicable]	[not applicable]
				Transitional river	[not applicable]	[not applicable]
				Rejuvenated bedrock fall	[not applicable]	[not applicable]
			Hillslope seep	[not applicable]	With ch. outflow	[not applicable]
					Without ch. outflow	[not applicable]
			Depression	[not applicable]	Exorheic	With ch. inflow
						Without ch. inflow
					Endorheic	With ch. inflow
						Without ch. inflow
					Dammed	With ch. inflow
						Without ch. inflow
		VALLEY FLOOR	Channel (river)	Mountain stream	[not applicable]	[not applicable]
				Transitional river	[not applicable]	[not applicable]
				Rejuvenated bedrock fall	[not applicable]	[not applicable]
				Upper foothill river	[not applicable]	[not applicable]
				Lower foothill river	[not applicable]	[not applicable]
				Lowland river	[not applicable]	[not applicable]
				Rejuvenated foothill river	[not applicable]	[not applicable]
				Upland floodplain river	[not applicable]	[not applicable]
			Channelled valley-bottom wetland	Valley-bottom depression	[not applicable]	[not applicable]
				Valley-bottom flat	[not applicable]	[not applicable]
			Unchannelled valley-bottom wetland	Valley-bottom depression	[not applicable]	[not applicable]
				Valley-bottom flat	[not applicable]	[not applicable]
			Floodplain wetland	Floodplain depression	[not applicable]	[not applicable]
				Floodplain flat	[not applicable]	[not applicable]
			Depression	[not applicable]	Exorheic	With ch. inflow
						Without ch. inflow
					Endorheic	With ch. inflow
						Without ch. inflow
					Dammed	With ch. inflow
						Without ch. inflow
			Valleyhead seep	[not applicable]	[not applicable]	[not applicable]
		PLAIN	Channel (river)	Lowland river	[not applicable]	[not applicable]
				Upland floodplain river	[not applicable]	[not applicable]
			Floodplain wetland	Floodplain depression	[not applicable]	[not applicable]
				Floodplain flat	[not applicable]	[not applicable]
			Unchannelled valley-bottom wetland	Valley-bottom depression	[not applicable]	[not applicable]
				Valley-bottom flat	[not applicable]	[not applicable]
			Depression	[not applicable]	Exorheic	With ch. inflow
						Without ch. inflow
					Endorheic	With ch. inflow
						Without ch. inflow
			Flat	[not applicable]	[not applicable]	[not applicable]
		BENCH (HILLTOP / SADDLE / SHELF)	Depression	[not applicable]	Exorheic	With ch. inflow
						Without ch. inflow
					Endorheic	With ch. inflow
						Without ch. inflow
			Flat	[not applicable]	[not applicable]	[not applicable]

NOTE: 2nd row of Table provides the criterion for distinguishing between wetland units in each column
* ch. = channelled (outflow/inflow)

1.4.6 Assessment of the sensitivity and conservation importance of wetlands

An essential component of the baseline assessment of wetland systems provided in this report is the assessment of wetland sensitivity and conservation importance, against which the significance of all potential impacts associated with the proposed nuclear developments and their associated activities is measured.

FCG's assignment of wetland **conservation importance** had as a starting point the recognition that most wetlands, even in a degraded condition, are potentially conservation-worthy. Some of the ecological, hydrological and socio-economic functions attributed to wetlands include the following (Davies and Day 1998):

- Contributing to perenniality of stream systems, through retention and slow release of waters during low flow periods;
- Flood attenuation – effected by retention of flood waters in wetland soils, and reduction of flood velocities through dissipation of flows through wide, vegetated areas;
- Improving water quality, through uptake and absorption of nutrients and other contaminants often found in surface runoff;
- Trapping sediment and reducing erosion of stream channels;
- Provision of natural resources (e.g. reeds for weaving; fish; other animals for food; medicinal plants; clean water);
- Provision of educational and tourism resources;
- Provision of habitat to wetland-associated animals and plants, many of which rely exclusively on these areas for breeding, feeding or nursery areas (Cowan 1995); and
- Provision of corridors for movement between terrestrial natural areas, or along river systems.

It is noted that since even artificial wetlands can often perform valuable ecological or other functions, and in light of the large-scale loss of natural wetlands, this assessment makes no automatic distinction between "natural" and "artificial" wetlands in its assessment of conservation status.

It should be stressed however that few if any wetlands perform all of the above functions; moreover, some wetlands do not perform any of these functions.

A number of protocols exist for the assessment of wetland conservation importance and condition, with different protocols having been developed for particular wetland types and conditions, as well as to allow measurement of particular aspects of wetland function, structure or their value to the management of human socio-economic structures or activities. In this study, efforts have been made to select the methodology most appropriate to the wetland types at each site, as well as methodologies that will best allow objective assessment of the implications of different impacts associated with the proposed developments, within the time constraints of the overall project.

The assessment protocols selected have all been developed in South Africa and are currently being used in wetland assessment here. They all aim to provide a measure of either or both the present condition, value and / or conservation-worthiness of the wetlands in question.

DWAF (1999) defines wetland **ecological importance** as "an expression of its importance to the maintenance of ecological diversity and functioning on local and wider scales" and "sensitivity" as "the extent to which the biota is able to accommodate change in the major physic-chemical features of the system". Arcus GIBB requested however that specialists engaged in the present study make use of the following (compatible) definition / description of sensitivity:

- *Sensitivity refers to the "ability" of an affected environment to tolerate disturbance. For example, if [anthropogenic] disturbance of the wetland would result in the permanent loss of biodiversity, then the affected environment could be categorised as having a "low tolerance" to disturbance and is, therefore, termed a highly sensitive habitat. If, on the other hand, a habitat is able to withstand significant disturbance without a marked impact on its biodiversity, the affected environment could be categorised as having a high tolerance to disturbance (i.e. "low sensitivity" habitat).*

The method used by DWAF to assess **ecological importance and sensitivity (EIS)** of wetlands in this study is a refinement of the DWAF Resource Directed Measures for Water Resources: Wetland Ecosystems method (DWAF 1999). It includes an assessment of ecological (e.g. presence of rare and endangered fauna / flora), functional (e.g. groundwater storage / recharge) and socio-economic criteria (e.g. human use of the wetland). The methodology has been adapted to allow for broad-scale EIS assessments of wetlands other than the specific floodplain wetlands for which the methodology was originally developed. The protocol for these assessments are summarised in Appendix B.

Two approaches were taken to the assessment of wetland **condition**. Both result in the assignment of a wetland to one of six Present Ecological State (PES) categories, as defined in DWAF's (1999) Reserve Determination methodology. However, the assessment protocols are not uniformly applicable to all wetland types. The following protocols were followed:

WET-Health (as described in Mc Farlane *et al*. 2008) was used to assess large, valley bottom wetlands, where these occurred on the sites. WET-Health is a tool designed to assess the health or integrity of a wetland as a measure of deviation from the wetland's natural or reference condition (Mc Farlane *et al*. 2008). The tool assesses hydrological, geomorphological and vegetation integrity or health, in three separate modules. For each of these factors, a magnitude-of-impact score is calculated. Scores for each factor are interpreted by categorisation into one of six Present State Categories (Table 1.2).

A first step in the WET-Health process is the characterisation of hydrogeomorphic (HGM) units, defined on the basis of wetland type and function. Each HGM unit is assessed separately in the Wet-Health application. Appendix C outlines the basic precepts of the WET-Health methodology.

The WET-Health tool allows a detailed level of wetland assessment. It is, however time-consuming and is applied with difficulty to smaller mosaic wetlands.

The desk-top PES methodology, adapted from Appendix W4 of the DWAF Resource Directed Measures for Water Resources: Wetland Ecosystems (DWAF 1999), was used to assess PES for all the wetland systems besides the large valley bottoms assessed with Wet-Health – specifically, groundwater-fed depressional and small seepage wetlands, for which WET-Health in its current form is not ideally recommended (Dr H. Malan, Freshwater Research Unit, University of Cape Town, ongoing reviewer of application of WET-Health methodology, pers. comm.). The methodology used in the PES assessment is outlined in Appendix D. It is based on a comparison of current attributes of the wetland against those of a desired baseline or reference condition. Table 1.3 presents the relationship between PES scores and PES category, for comparison with the WET-Health categories.

Table 1.2 Description of the Present Ecological State categories of WET-Health, showing the range of magnitude-of-impact scores used to categorise each HGM unit assessed. Table after Mc Farlane *et al*. (2008).

DESCRIPTION	WET-Health IMPACT SCORE	PRESENT STATE CATEGORY
Unmodified, natural.	0 – 0.9	A
Largely natural with few modifications. A slight change in ecosystem processes is discernable and a small loss of natural habitats and biota may have taken place.	1 – 1.9	B
Moderately modified. A moderate change in ecosystem processes and loss of natural habitats has taken place but the natural habitat remains predominantly intact	2 – 3.9	C
Largely modified. A large change in ecosystem processes and loss of natural habitat and biota and has occurred.	4 – 5.9	D
The change in ecosystem processes and loss of natural habitat and biota is great but some remaining natural habitat features are still recognizable.	6 – 7.9	E
Modifications have reached a critical level and the ecosystem processes have been modified completely with an almost complete loss of natural habitat and biota.	8 – 10	F

Table 1.3 Interpretation of PES score, using the DWAF (1999) methodology.

PES Score	Wetland Description	PES Category	
> 4	Unmodified or approximates natural condition	A	Acceptable Condition
> 3 <=4	Largely natural with few modifications, minor loss of habitat	B	
> 2 <=3	Moderately modified with some loss of habitat	C	
= 2	Largely modified with loss of habitat and wetland functions	D	
> 0 < 2	Seriously modified with extensive loss of habitat and wetland function.	E	Unacceptable Condition
0	Critically modified. Losses of habitat and function are almost total, and the wetland has been modified completely.	F	

2 DESCRIPTION OF THE AFFECTED ENVIRONMENT

2.1 Duynefontein[2]

2.1.1 Site overview and context

The proposed Duynefontein site includes the present Koeberg Nuclear Power Station (KNPS), and lies some 8km north of Melkbosstrand, on the sandy coastal plain of the West Coast (Figure 2.1). The vegetation across most of the site has been classified as Cape Flats Dune Strandveld vegetation (Mucina and Rutherford 2006), with Atlantis Sand Fynbos occurring in the southern and eastern portions of the site (Low 2009). No rivers flow through the site, and the closest drainage line of significance is the Sout River and its largest tributary, the Donkergatspruit. The Sout River enters the sea at Melkbosstrand, south of the site.

Two aquifers underlie the site. The upper primary or intergranular aquifer is some 13m thick, and comprises the southern extent of the Atlantis Aquifer (SRK 2007). The lower (secondary) aquifer comprises weathered and fractured rocks of the Malmesbury Group. Groundwater levels on the site are shallow, reflecting the fact that groundwater on the site is at the end of its flow path, with the area immediately adjacent to the coastline comprising a groundwater discharge zone (SRK 2007). Typical of coastal aquifers, the groundwater is sodium-chloride dominated, and SRK (2007) describes it as slightly saline, with EC in the range 270-305 mS/m – again indicating a coastal influence.

The shallow water table on the site has given rise to a number of surface wetlands, which are fed primarily by groundwater, with surface water contributions expected to be limited, given the high porosity of the sandy substratum (SRK 2007). Wetland habitat is defined primarily by low-lying areas where groundwater is seasonally or perennially exposed.

2.1.2 General description of wetland ecosystems associated with the site

All of the wetlands identified on the Duynefontein site are classified in terms of the National Wetland Classification (SANBI 2009) as **wetland depressions,** which occur within a largely flat landscape, indicative of a **plain** landscape setting.

Two categories of depressional wetlands were identified on the basis of Level 5 and 6 criteria in the NWCS, namely:

[2] Note that the wetland descriptions and baseline data presented in this section, for the Duynefontein site, have already been presented in Day (2009) for the assessment of the proposed Pebble Bed Modular Reactor Demonstration Power Plant on the same site – the terms of reference for the latter specifically allowed for presentation of these data in this report.

Seasonal wetlands (Sw), most of which are located in the south western portion of the site (Figure 2.2: Sw1-Sw7), where they are separated from the coast by a line of low dunes, and collectively comprise an extensive mosaic of seasonally inundated duneslack wetland. Two bands of this mosaic wetland can be distinguished, along with a number of more isolated depressions, viz:

- Sw1 - the wetland flats immediately adjacent to the coast, which have probably been flattened to some extent by an access road along their edge
- Sw2 - a series of shallow, seasonally inundated depressions east of a low-lying dune ridge. Inundated portions of the depression are edged by reedbed or seasonally saturated wetland vegetation, with, in places, small terrestrial hillocks and shallow ridges separating the wetland units.
- Sw3, Sw5, Sw6 and Sw7 - isolated seasonally saturated or inundated depressional wetlands to the north and east Sw1 and Sw2, as well as on the dune fields in the north of the Duynefontein site.

> Auguring of wetlands Sw1, Sw2 and Sw3 showed that their soils comprised a fine to medium grained sands to some 60cm below the surface. During the 2007/2008 dry season, these sands were saturated at 30cm below the surface, with standing water at 35cm bgl.

Artificial wetlands, which are the product of past human activities on the site. These include one seasonally inundated depression (Sw4), created along the main NPS access road, but mainly comprise permanently inundated to saturated wetlands which, occur in the vicinity of the existing Koeberg NPS, in places along internal roads, along the boundary fence line and in the northern portion of the site, just north of the dune field (Figure 2.2 – Sw4 and P1-P7).

The locations of the wetlands described above are shown in Figure 2.2. The individual extents of the Sw1 and Sw2 wetlands have not however been mapped. These wetlands occur as multiple depressions within a mosaic of low dunes and slightly raised hillocks, and as a result the entire mosaic area is regarded as wetland and critical wetland support areas. Detailed mapping of individual units would be highly complex, and contribute little of value to the aims of this project. Thus Figure 2.2 indicates the broad outer extent of the southern wetlands, and highlights only individual depressions, from where water quality or invertebrate samples were collected.

The Sw1 and Sw2 wetlands run parallel to the coast in the southern portion of the site. Beyond the site itself, their extent has been impacted by the Duynefontein residential development to the south, and an unquantified area of these wetlands has been lost. Within the Duynefontein site itself, a large proportion of these seasonal wetlands were in the past heavily invaded by woody alien plants. Clearing of this vegetation approximately 10 years ago, and subsequent maintenance of cleared areas, has resulted in a return to a more natural, longer hydroperiod, the re-establishment of wetland vegetation and overall recovery of wetland habitats within these areas (Mr Gert Greeff, Eskom, pers. comm.).

Other portions of the site have been impacted by past activities associated with the construction of the present Koeberg NPS. The area between the mosaic of seasonal wetlands in the south of the site and the NPS itself, for example, probably once also included portions of seasonally inundated wetland. The area was however used as a lay down area during construction of the Koeberg NPS and today comprises a flattened, homogeneous, disturbed area, portions of which have been mapped as degraded *Ficinia nodosa* wetland flats (Figure 2.2). Auguring of these wetland soils indicated high levels of gravel and other fill just below the vegetated surface. This material is assumed to be remnant impacts from the construction phase of the Koeberg NPS.

In the mobile dune areas, with the exception of Sw7, which lies at the north eastern side of the dune (Figure 2.2), no actual wetland habitats were found. A "blow-out" on the western side of the mobile dune has resulted in the creation of low-lying areas supporting scant patches of vegetation often associated with the margins of wetlands (e.g. *Ficinia nodosa*). These areas are not considered to be wetlands, although their presence does indicate the dynamic nature of habitats in mobile dune systems, and it is possible that in wetter conditions or if the blow-out results in deepening of the duneslack depression, these may in time provide wetland habitat.

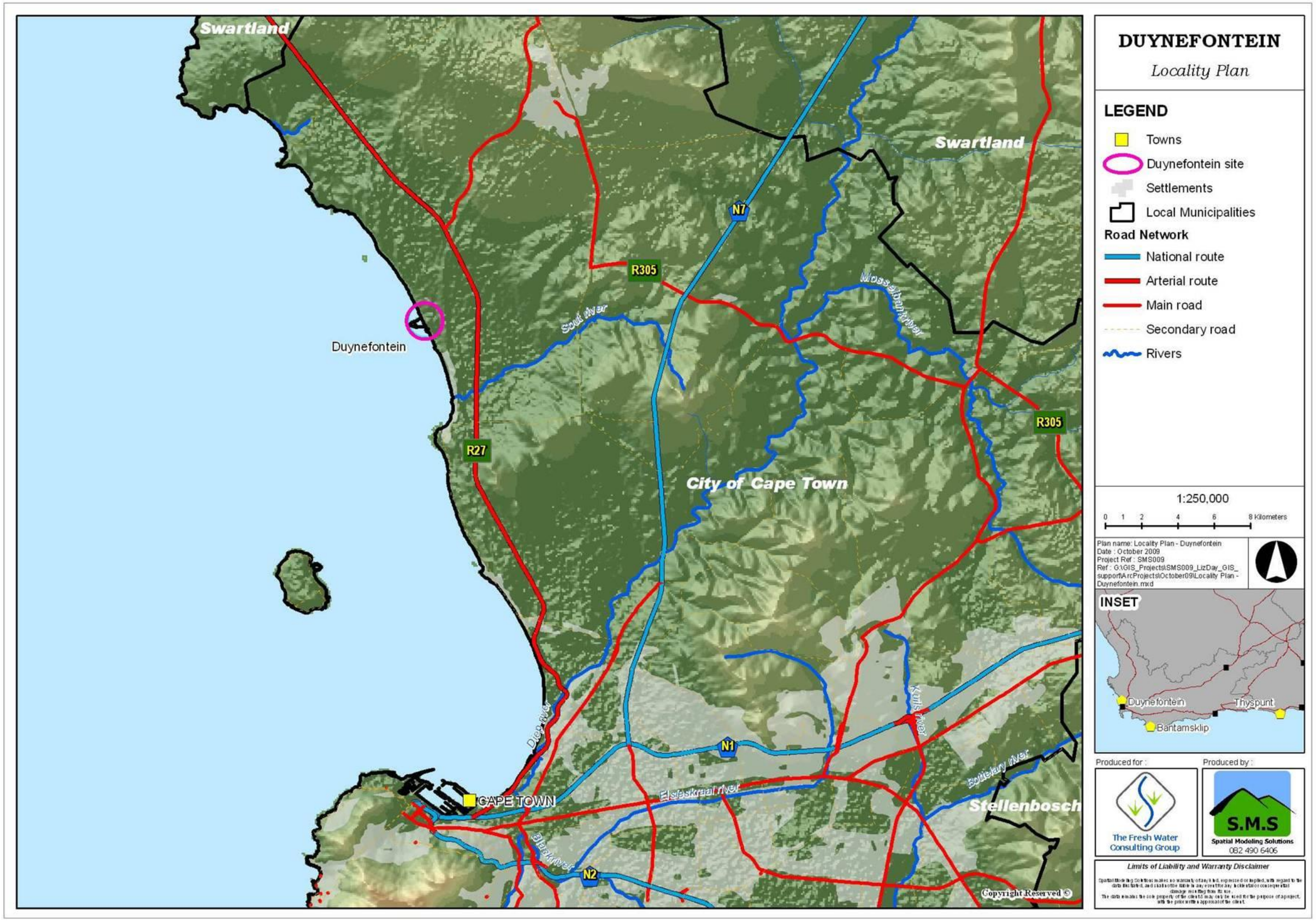


Figure 2.1 Site context of Duynefontein

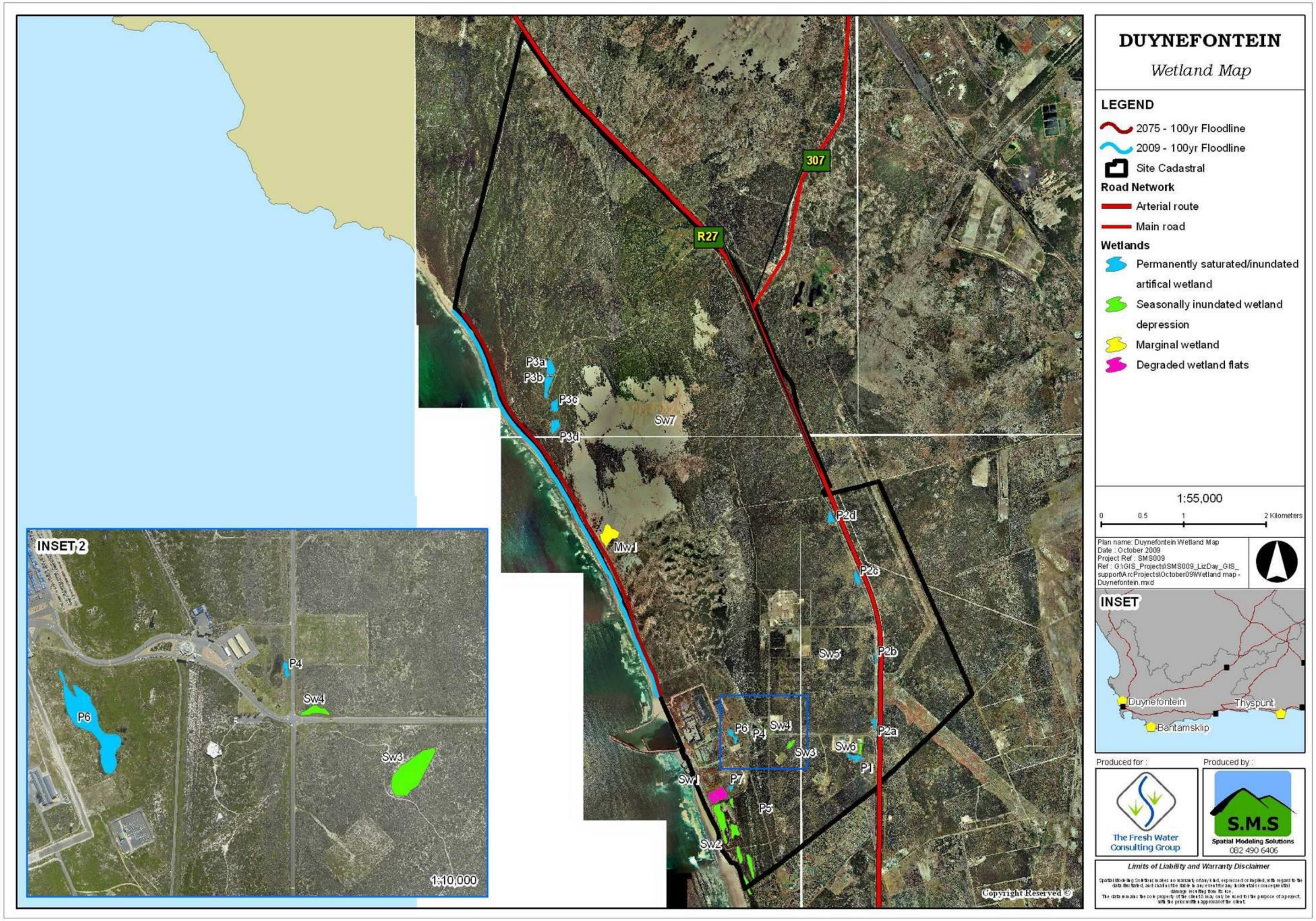


Figure 2.2 Mapped extent of wetlands occurring on the Duynefontein site. Inset 1 shows the site location in relation to the other potential sites. Inset 2 shows an enlargement of the area defined by the blue box in the main figure.

2.1.3 Description of the characteristics of wetland types based on data from selected representative wetlands

Approach

A representative number of wetlands were selected for detailed sampling of water chemistry and, where conditions were appropriate, collection of aquatic and semi-aquatic invertebrates. These covered the major wetland types, within the two main categories of wetland on the site - seasonally inundated / saturated wetlands and (largely artificial) permanently inundated / saturated wetlands.

Table 2.1 presents water chemistry data from sampled sites. Samples were collected in the wet seasons of 2007 and 2009, representing early wet season conditions, (i.e. when wetlands had only recently been inundated).

Table 2.1 Water quality in sampled wetland sites at Duynefontein

Variable	Date	Sw1	Sw2	Sw3	P2a	P1
Potassium as K mg/L	*July 2009*	*35*	*62*	*21*	*67*	
Sodium as Na mg/L	*July 2009*	*839*	*1211*	*833*	*2096*	
Calcium as Ca mg/L	*July 2009*	*151*	*264*	*182*	*225*	
Magnesium as Mg mg/L	*July 2009*	*104*	*167*	*124*	*284*	
Ammonia as N mg/L	*July 2007*	<0.025	<0.025	4.857		0.035
	July 2009	*<0.1*	*0.2*	*<0.1*	*0.1*	
Sulphate as SO4 mg/L	*July 2009*	*259*	*515*	*312*	*1190*	
Chloride as Cl mg/L	*July 2009*	*1390*	*2210*	*1610*	*3650*	
Alkalinity as CaCO3 mg/L	*July 2009*	*496*	*439*	*261*	*171*	
Nitrate plus nitrite as N mg/L	*July 2007*	<0.025	<0.025	<0.025		<0.025
	July 2009	*<0.05*	*<0.05*	*<0.05*		
Ortho phosphate as P mg/L	*July 2007*	0.042	0.149	0.138		0.055
	July 2009	*0.10*	*0.09*	*0.09*		
Total phosphorus as P mg/l	*July 2007*	131	194	571		129
Electrical conductivity (EC) mS/m	*July 2007*	221	290	364		452
	July 2009	*456*	*640*	*546*	*980*	
pH	*July 2007*	7.6	8.1	6.8		9.07
	July 2009	8.2	8.0	7.7	10.4	
Kjeldahl Nitrogen as N mg/L	*July 2009*	*4*	*3*	*2*	*3*	
CATIONS meq/L	*July 2009*	*53.45*	*81.20*	*56.08*	*127.47*	
ANIONS meq/L	*July 2009*	*54.52*	*81.84*	*57.14*	*131.16*	

Table 2.2 provides summary descriptions of trophic state indicators in aquatic ecosystems, with respect to phosphorus and nitrogen nutrient concentrations.

Invertebrate samples were collected at the selected sites in July 2007 and again during early spring (August / September) 2008, the latter date representing a more developed invertebrate community, established over a longer time period since inundation than in the case of the 2007 samples. Day *et al.* (2009) note the important role that timing plays in the collection of aquatic invertebrate community data for seasonal wetlands, with some taxa emerging immediately following inundation, and others responding to cues of prolonged inundation before hatching from desiccation-resistant eggs.

Invertebrate taxa collected at sampled wetlands are listed in Table 2.3.

Table 2.2 Summary of ranges of phosphorus and/or nitrogen-based nutrients associated with different trophic conditions in aquatic ecosystems
Inorganic nitrogen ranges from DWAF (1996); phosphorus from DWAF (2002)

Trophic state	**Effects**	**Average summer inorganic <u>nitrogen</u> concentrations (mg/l)**	**Average summer inorganic <u>phosphorus</u> concentrations (mg/l)**
Oligotrophic	Moderate levels of species diversity; usually low productivity systems with rapid nutrient cycling; no nuisance growth of aquatic plants or the presence of blue-green algae	<0.5	< 0.015
Mesotrophic	Usually high levels of species diversity; usually productive systems; nuisance growth of aquatic plants and blooms of blue-green algae; algal blooms seldom toxic	0.5 - 2.5	> 0.015-0.047
Eutrophic	Usually low levels of species diversity; usually highly productive systems; nuisance growths of aquatic plants and blue-green algae, algal blooms may include species that are toxic to man, livestock and wildlife	2.5-10	>0.047-0.130
Hypertrophic	Usually very low levels of species diversity; usually very highly productive systems; nuisance growths of aquatic plants and blue-green algae, algal blooms may include species that are toxic to man, livestock and wildlife	>10	> 0.130

Table 2.3 Invertebrate taxa from sampled seasonal wetland sites at the Duynefontein site
Samples collected in July 2007 (Sw1 and 2) and early spring 2008 samples (KOE 1-6)
2008 Data collected as part of the WRC WHI Programme (Bird 2009) (see also Appendix E)
Taxa abundance codes as follows: A=1 individual; B=2-10; C=11-20; D=21-100; E>100

Group/Order	Family	Taxon	Sw1	Sw2	KOE 01	KOE 02	P1	KOE 03	KOE 04	KOE 05	KOE 06	Common Names
					(=Sw1)	(=Sw2)		(southern wetland mosaic)				
Acarina	unknown	Hydracarina spp.				A						water mites
Anostracoda	Streptocephalidae	*Streptocehalus purcelli*				A						fairy shrimps
Cladocera	Daphniidae	*Daphnia barbata*				D						water fleas
		Daphnia dolichocephala			A	A		A	A	D		
		Daphnia pulex/obtusa									A	
		Simocephalus spp.									A	
	Macrothericidae	*Echinisca* sp.		A		E						
		Macrothrix propinqua			A	D				A		
	Moinidae	*Moina brachiata*						A	A		A	
		Moina micura	D	D								
		Moina sp.						A	A		A	
Coleoptera	Curculionidae	Curculionidae sp. adult	B	A								weevils
	Dytiscidae	Bidessini sp. larva				B						tiger beetles
		Canthyporus spp. adult								A	B	
		Canthyporus hottentottus adult			A			A		A		
		Darwinhydrus solidus adult						A				
		Derovatellus sp. adult		A			A					
		Hydropeplus sp. adult			A							
		Hydroporus sp. adult	B	A								
		Hydroporus sp. larva	B	B								
		Hydrovatus sp. larva				B						
		Laccophilus cyclopis							A			
		c.f. Neoporus sp. larva	D	D			A					

Group/Order	Family	Taxon	Sw1	Sw2	KOE 01	KOE 02	P1	KOE 03	KOE 04	KOE 05	KOE 06	Common Names
					(=Sw1)	(=Sw2)		(southern wetland mosaic)				
		Rhantus sp. larva	B	C		A						
	Gyrinidae	*Aulonogyrus capensis*								A		whirlygig beetles
	Hydrophillidae	*Berosus* sp. larva		B								water scavenger beetles
		c.f. Sperchopsis sp.	A									
Conchostraca	Leptestheriidae	*Leptestheriella rubidgei*			A	A						clam shrimps
Copepoda: Calanoida	Diaptomidae	*Lovenula simplex*			A	A		A	A	A		-
		Metadiaptomus capensis			A	D		A	A	D		
		Paradaptomus lamellatus				B				C		
Copepoda: Cyclopoida	Cyclopodia	Cyclopodia sp.	A									-
		Microcyclops crassipes		C	A	A		A	A	C	A	
Diptera	Chironomidae: Chironominae	*Polypedilum* sp. larva	B	B		C	A					non-biting midges
		Tanytarsus sp. larva				B						
		Tanytarsus sp. pupa				A						
	Chironomidae: Orthocladiinae	*Corynoneura* sp. larva	B			A						
		Cricotopus sp. larva	A	B								
		Rheocricotopus sp. larva		A								
		Orthocladiinae spp. larva				B		A	A	A	A	
	Chironomidae: Tanypodinae	*Ablabesmyia* sp. larva								B		
		Paramerina sp. pupa		B								
		Tanypodinae spp. larva			A	A		A				
	Culicidae: Culicinae	*Aedes* sp. larva	C									mosquitoes
		Culicidae spp. pupa				A		A	A		A	
		Culex spp. larva		D				A	A		A	
		Culiseta sp. larva	B	B				A	A		A	

Group/Order	Family	Taxon	Sw1	Sw2	KOE 01 (=Sw1)	KOE 02 (=Sw2)	P1	KOE 03 (southern wetland mosaic)	KOE 04	KOE 05	KOE 06	Common Names
	Dixidae	*Dixa* sp. larva								A		meniscus flies
	Stratiomyidae	*Odontomyia* sp. larva		A								soldier flies
		Stratiomyidae sp. larva						A	A	A		
Ephemeroptera	Baetidae	*Cloeon* sp.	B	D	A	A	C	A	A	A	A	minnow mayflies
Haplotaxida: Tubificina	Tubificidae	Tubificidae sp.	C									worm
Hemiptera	Corixidae	*Sigara* sp.		A		A	C					waterboatman
		Sigara meridionalis						A			A	
		Sigara pectoralis			A	A		A	A			
	Notonectidae	*Anisops* sp.		B								backswimmers
		Anisops sardea			A	A		A	A	A		
		Notonecta lactitans			A				A	A		
	Pleaidae	*Plea piccanina*			A				A	A	A	pygmy backswimmers
		Plea pullula							A	A	A	
		Plea sp.		A								
Anisoptera	Coenagrionidae	Coenagrionidae sp.					B					damselflies
Mesogastropoda	Physidae	*Physia acuta*									A	snails
	Planorbidae	*Bulinus tropicus*						A				
	Pomatiopsidae	*Tomichia* sp.			A	A		A	A	A	A	
		Tomichia ventricosa		C						D		
Ostracoda		*Chrissia* sp. A			A	A		A	A	A		seed shrimps
		Cypricercus episphaena			A	A		A	A	A	A	
		Heterocypris sp. A				A		A	A	A	A	
		Ostracoda sp. 1	D	C			B					
		Ostracoda sp. 2	D			B						
		Ostracoda sp. 3	A			B				E		
		Ostracoda sp. 4		A		A				C		
		Ostracoda sp. 6								C		

Group/Order	Family	Taxon	Sw1	Sw2	KOE 01	KOE 02		KOE 03	KOE 04	KOE 05	KOE 06	Common Names
					(=Sw1)	(=Sw2)	P1	(southern wetland mosaic)				
		Paracypretta sp. A			A	A		A		A		
		Potamocypris? sp. 1								E		
		Pseudocypris acuta			A	A			A			
		Sarsypridopsis sp. A				A		A	A			
		Zonocypris cordata			A	A		A	A	A	A	
Rhabdocoela	unknown	*Mesostoma?* sp.								C		flat worms

The following sections describe in more detail the characteristics of the seasonally and permanently inundated to saturated wetland types, based on field data collected from representative wetlands.

A Characterisation and assessment of seasonally inundated wetland depressions

Water chemistry samples were collected from three examples of this wetland type, Sw1 (Photo Da), Sw2 (Photo Db) and Sw3. The locations of these sites are shown in Figure 2.2. Aquatic invertebrate fauna were also sampled at sites Sw1 and Sw2, but water levels in Sw3 were too low at the time of sampling to allow sampling of macroinvertebrates. Water chemistry and invertebrate faunal data for the assessed sites are listed in Tables 2.1 and 2.3 respectively.

Broad habitat descriptions

The wetlands in this category are fed primarily by a seasonally fluctuating water table, which forms pools of shallow, fresh to brackish water during winter. The pools provide breeding habitat for frogs (too juvenile to be identified in this study) as well as numerous aquatic and semi-aquatic invertebrates, described in more detail below and listed in Table 2.3. The pools dry out in summer as the water table recedes.

These sampled wetlands are considered to be similar in character and functioning to the other seasonal wetlands identified on the site, and indicated in Figure 2.2 (i.e. all the other patches adjacent to Sw1 and Sw2, as mapped).

Photo D_a
Wetland Sw1 in late winter 2007

Low (2009) has provided detailed descriptions of the plant communities that occur within and associated with the seasonally inundated depressional wetlands. Dominant plants in seasonally inundated habitats included *Sarcocornia* sp., *Juncus kraussii* and *Bulboschoenus maritimus,* while the drier wetland margins were dominated by *Ficinia nodosa*. Stands of *Orphium frutescens* were abundant on the upper wetland margins – particularly along the northern (roadside) edge of the mapped seasonal wetland mosaic Sw1 and Sw2 shown in Figure 2.1. Dense *Typha capensis* reedbeds occurred in places within the wetland mosaic.

Photo D_b
Wetland Sw2 in late winter 2007. Note mosaic of inundated depressions in background.

Water chemistry

Salinities in the seasonal wetlands in the south-western portion of the site, represented by Sw1 and Sw2, varied between relatively fresh (<300mS/m) and quite brackish, reflecting different levels of dilution and evapoconcentration in different years.

Unpublished FCG data collected in late summer 2008 indicate that EC in Sw1 and Sw2 reached at least to 1142mS/m and 1433mS/m respectively before they dried out altogether. The presence of *Sarcocornia* sp. (a plant species indicative of brackish to saline conditions) along the margins of many of the wetland depressions confirms that salinity increases annually, as the wetland dries out. A combination of evaporative concentration and marine influences such as sea mists and off-shore winds probably contribute to periodically raised salinities. Unsampled wetlands adjacent to Sw1 and Sw2, but closest to the sea, were most saline, as evidenced by the dominance of *Sarcocornia* and other salt-tolerant plants in these areas, with salinities up to 1502 mS/m in late summer 2008 (FCG unpublished data).

Comparison of molar concentrations of major anion and cation data (from Table 2.1) shows that these wetlands, like the groundwater (SRK 2009) are ionically sodium-chloride dominated, and supports the suggestion that they are fed primarily by groundwater, although direct (overhead) rainfall may bring about a measure of surface water dilution. Unlike the aquifer, however, the wetlands are prone to dry season evapoconcentration and the accumulation of windblown marine salts on their surfaces, resulting in periods when salinities are higher in the wetlands than in the underlying groundwater.

Phosphate concentrations in the wetlands fell within the range suggested by DWAF (2002) as indicative of mesotrophic to eutrophic conditions (Table 2.2). It is noted however that these guidelines were derived from lotic systems (i.e. rivers) rather than lentic (non-flowing) wetland depressions, and the ranges for different trophic states have not been determined in South Africa for specific wetland types (Malan and Day 2005). A survey of some 150 other wetland depressions in the Cape Town area (Bird 2009) suggested that in fact most of this type of wetland depression exhibits concentrations of phosphorus that are higher than those linked to mesotrophic conditions in Table 2.2, without necessarily giving rise to the ecological conditions usually described as being associated with eutrophication.

Nitrogen enrichment was low at the assessed sites, at concentrations where this nutrient might even be limiting at the site.

Concentrations of nitrogen, and to a lesser degree phosphorus nutrients, were much greater at Sw3 than the other sites. Here, particularly high concentrations of ammonium (NH_4-N) combined with low levels of NO_3-N probably reflect the fact that the water levels in the water were very low at the time of sampling, with low levels of oxygenation and a relatively high proportion of organic material in the bottom of the wetland. Such conditions limit the rate of oxidation of ammonium to nitrite and then nitrate, resulting in characteristically high ammonium concentrations. Phosphorus concentrations were also higher at this site than in the case of both Sw1 and Sw2, falling within the range suggested by DWAF (2002) as indicative of hypertrophic conditions – although the caveats already mentioned regarding the applicability of these trophic guidelines to seasonally inundated wetland depressions apply.

Aquatic invertebrate fauna

Of the six seasonally inundated wetlands from which invertebrate data were collected over the 2007/2008 wet seasons, 80 taxa were identified, including a number of "morpho taxa", not identified to species (Table 2.3). Twenty nine of these taxa were microcrustaceans – a group that characterises many seasonally inundated wetlands (Day et al. 2009) and, in the Western Cape, may include a number of regional or even local endemics (Day et al. 2007). Ten microcrustacean species were from the subclass Branchipoda, including nine cladoceran and one conchostracan species. Day et al. (2009) noted that hydroperiod appeared to be one of the key factors determining the presence or absence of branchiopod fauna in wetlands, and correlated their presence in wetlands with those systems that dried out completely during summer, exhibiting dry season soil moisture of <10%.

A possible 13 ostracod species or morpho-species were also identified in the seasonally inundated wetlands. This group is found in a wide range of habitats, and is very common in temporary systems (Schael 2008). This said, the Western and Eastern Cape are known to have several endemic ostracod species, and few species are regarded as cosmopolitan (Martens 2001). There is thus a good possibility that improved taxonomic information in the future will result in the identification of endemic ostracod species at this site.

Invertebrate samples collected early on in the wet season of 2007 showed much lower numbers of microcrustacean fauna in general, than did samples collected later in the wet season of 2008. It is assumed that these differences reflected the time taken for some microcrustacean fauna to respond to inundation cues. Day et al. (2009) reported that hatching of microcrustacean fauna under laboratory conditions took from a few days to 35 days, following artificial inundation of soil samples. The 2007 sample may simply not have been inundated long enough for the full invertebrate community to be visible. Microcrustacean numbers in the 2007 samples were thus dominated by numbers by the cladoceran, *Moina micrura* –cosmopolitan, benthic cladocerans found in ponds and temporary waters under saline conditions (Seaman *et al.* 2000). They have a short development time, are well suited to life in temporary systems, and respond rapidly to inundation cues (Day et al. 2009).

Typical of many seasonal wetlands, the invertebrate community in all seasonally inundated wetlands was however dominated by insect taxa, with Coleopterans and Dipterans being the most species-diverse groups present. The dominant coleopterans were from the Dytiscidae family - a group common in both temporary and permanent standing water bodies, (Epler 1996). The species found at sites Sw1 and Sw2 within the genus *Neoporus* (formerly part of *Hydroporus*), tend to be both habitat- and site-specific (Epler 1996), and are thus potentially associated with local endemism. At present, however, little is known about South African species (Schael 2008).

Non-biting midges (Chironomidae) and mosquitoes (Culicidae) were the dominant dipteran families, both of which have species that can inhabit a wide range of habitats.

The ephemeropteran mayfly *Cloeon* sp. was also found in relatively large numbers in the sample from Sw2. This genus of mayfly is common in temporary water bodies and has a wide salinity, temperature and oxygen level tolerance (Monaghan *et al.* 2005). Similarly, the snail, *Tomichia ventricosa,* which was found in Sw2 in large numbers and not in Sw1, is found predominately in seasonal pans and has a high tolerance of salinity (Brown 1994). The abundance of grazing material in Sw2 may have encouraged the large numbers of this species.

Appendix E compares the late winter 2007 and spring 2008 samples from the Duynefontein sites with those from other wetland depressions occurring both locally and regionally, and including sites from the other two Nuclear 1 study sites assessed in this report (i.e. Bantamsklip and Thyspunt). Whilst the 2007 samples were shown to be different largely as a consequence of the timing of the 2007 sampling, the spring 2008 samples were more appropriate for a regional comparison, as they were collected at the same time as the broader sample set.

The analysis presented in Appendix E showed that these Duynefontein samples formed part of a clearly defined group of wetlands from the west coast region of the Western Cape. The species composition of this grouping could be differentiated from other geographical areas in the region by the predominance of microcrustacean taxa, mainly from the Classes Cyclopoida, Ostracoda and Cladocera, as well as by chelicerate taxa of the Class Arachnida, which includes hydracaranid water mites.

The Duynefontein samples grouped tightly together, based on their species composition, along with the wetlands SOU2, 3 and 4, which were all taken from seasonal duneslack depressions in the near vicinity of the Duynefontein site, just west of the R47 at the turnoff to the Duynefontein residential area. This suggests that at a regional level, the particular habitat conditions associated with the Duynefontein wetland sites and those in the vicinity provide for distinct invertebrate community characteristics.

<u>Present ecological status of seasonally inundated wetlands</u>

Wetlands Sw1 and Sw2, assessed within their broader mosaic of seasonally saturated margins and low dunes, fell within a PES category of A/B – that is, one that is largely unmodified and believed to approximate their natural condition.

The PES of the marginally more disturbed Sw3 fell within the range of Category B wetlands – that is, still largely natural with few modifications and with only minor loss of habitat, when compared to a conceptual reference condition.

Besides the wetland depressions that occur within the wetland mosaic represented by Sw1 and Sw2, and the isolated depression represented by Sw3, only four other areas of seasonally inundated, natural depressional wetlands were found during the course of this study. These are marked in Figure 2.2, and comprise:

- Sw4 – a shallow depression immediately north of the main Koeberg access road, the margins of which were enlarged during the construction of the adjacent access road;
- Sw5 – a relatively small, isolated depression / duneslack wetland area, the margins of which are moderately invaded by alien *Acacia saligna*;
- Sw6 – this is a relatively small area of very shallow (probably <150cm) seasonally inundated wetland flats, in the vicinity of the helicopter landing pad, near to the main KNPS entrance off the R47. The wetlands have been impacted by occasional vehicle traffic and other impacts; and
- Sw7 – this wetland occurs at the toe of a dune on the eastern edge of the northern mobile dunefield (Figure 2.2). The wetland has developed over the last few years (G. Greeff, Eskom, pers. comm.), and comprised (in spring 2009) a shallow, seasonally inundated wetland, densely vegetated with a variety of

wetland plants, dominated by *Ficinia nodosa and Isolepis antarctica* and with *Helichrysum* sp. and *Senecio helimifolius* on the wetland margins. It supported numerous (unidentified) tadpoles. At the time of the site visit, the mobile dune was visibly advancing over the wetland edge.

Of the above wetlands, Sw7 was assessed as a PES category of A/B; Sw4 and Sw5 were both scored within the range of a PES category B – that is, largely natural, with few modifications in habitat. The PES score for Sw6 fell within the range of a Category C wetland – one that has been moderately modified from its natural condition. (See Appendix A for description of PES scores).

Links with other wetland types

The seasonally inundated wetland depressions on the site are set within a broader mosaic of habitats dominated by seasonally saturated to moist wetland, separated by shallow dune ridges and other slightly elevated terrestrial areas (Photos D_c and D_d). In places, seasonally inundated habitats are edged by dense stands of *Phragmites australis* reedbed and, in places, *Typha capensis*. Dense stands of *Bulboschoenus maritimus* wetland flats also occur, particularly towards the southern end of the mosaic area.

Photo D_c (left) and D_d (below)
Mosaic of wetland depressions, low dune areas and seasonally saturated wetland margins (left). This mosaic area includes wetlands Sw1 and Sw2.

The seasonally saturated wetland margins surrounding depressions such as Sw1 and Sw2 act as a buffer to the seasonally inundated areas, protecting them from runoff and other impacts that might result from activities occurring in their catchment and immediate surrounds, as well as providing potentially important wetland habitat in its own right, likely to support semi-aquatic fauna. The habitat shrinks and expands with inundation and desiccation cycles, and with the expansion and contraction of terrestrial areas on both a seasonal and a long-term climatic basis. The assessment of wetland sensitivity and importance (below) is thus based upon this broader wetland mosaic.

The maintenance of links between individual wetland depressions and the surrounding terrestrial and wetland mosaic areas is considered an integral part of their function and biodiversity importance. Past linkages between the wetlands and the sea were probably also important, particularly for animals such as Cape Clawless Otters, which move habitually between coastal wetlands and the sea. Such linkages have, however, already been severed by the introduction of fences between the KNPS and the sea.

B Characterisation and assessment of permanently saturated to inundated depressions

All of the permanently inundated wetlands on the Duynefontein site are believed to be artificial in origin, and include a combination of:

Borrow pits, from which clay and other materials have been excavated in the past Examples of these are P1, just south and west of the first security check point on the main road in to the Koeberg NPS, and P2a-d along the fence line, immediately west of the R27. Of these, P1 and P2a were sampled for water chemistry, and P1 was sampled for aquatic invertebrates.

- P1 is a steep-sided, irregularly shaped depression, densely vegetated with indigenous pondweed (*Potamogeton* sp.). P2a is a shallow depression, with clayey substrate. It supports stands of reeds (*Typha capensis* and *Phragmites australis)* in deeper portions, which appear to retain standing water for longer.
- EC readings at the assessed wetlands indicated brackish conditions, with a high alkalinity. Like the seasonal wetlands (e.g. Sw1 and Sw2) to the west, water quality in the permanent wetlands was sodium-chloride dominated, but tended towards higher salinities. Elevated salinities were also noted in groundwater in the vicinity of P2a, with EC in groundwater sampled from two boreholes adjacent to P2a ranging between 1800 and 800 mS/m (SRK 2009), thus lending weight to the premise that the permanent wetlands are predominantly fed by groundwater. Elevated EC levels in this area of the site were attributed by SRK (2009) to the proximity of the boreholes to outcrops of Malmesbury shales, known to produce run-off with high EC.
- Nutrient data assessed from samples from these permanent wetlands indicate that the systems were mesotrophic to eutrophic with respect to phosphorus concentrations and with low levels of nitrogen enrichment (Table 2.1). The fact that both wetlands displayed elevated pH values (9.1 and 10.4 for P1 and P2a respectively) is of concern with regard to ammonium concentrations – at 20°C and pH 9, concentrations of [3]unionised ammonia (NH_3) measured in the wetland lie just within the range suggested by DWAF (1996) as indicative of acute toxicity to some aquatic fauna.
- Aquatic invertebrate diversity in P1 was low, and comprised relatively hardy taxa, dominated by air breathing hemipterans, but including large numbers of baetid mayflies (Ephemeroptera) and coenagrionid damselflies. Underlying clay /kaolin in these wetlands results in their retaining water throughout most of the year. Day et al. (2009) correlated the absence of several microcrustacean fauna from wetland habitats with extended hydro periods and sustained soil moisture.

---

[3] Two forms of ammonia occur: relatively harmless ammonium ions (NH_4^+) and toxic un-ionised ammonia (NH_3). At pH >8, a significantly larger proportion of total ammonia ions are present in the un-ionised form, which may give rise to acute toxicity at concentrations as low as 0.1 mg N/l (DWAF 1996).

Ostracods were in fact the only microcrustacean fauna that were identified in samples from P1 (Table 2.3).

A series of **coastal infiltration ponds** in the northern section of the Koeberg Nature Reserve, excavated between the dunes (P3a-d, Figure 2.2):

- These wetlands are fed by treated industrial effluent and untreated stormwater runoff, piped from the Atlantis industrial area (Day and Ewart-Smith 2005). A suspected link between the effluent pond closest to the sea and an observed increase in seepage from, and subsequent deterioration in, the limestone cliffs along a section of coastal shoreline nearby, resulted in reduced usage of this pond over the past 10 years (Day and Ewart-Smith 2005).
- The ponds are highly artificial habitats, with the first three (P3a-c) comprising deep, permanent, open-water bodies, vegetated by plant species that thrive under conditions of nutrient enrichment. They are edged by *Typha capensis* (the extent of which is limited by depth). Floating invasive aquatic weeds (e.g. *Lemna gibba*) occur on the pond surfaces, and the ponds are prone to occasional algal blooms, as well as outbreaks of so-called “blue-green algae” blooms (Day and Ewart-Smith 2005).
- The infiltration ponds provide permanent habitat to a variety of swimming waterfowl, although the scarcity of shallow water habitat make them of limited value to wading birds.
- Fish have been introduced to the ponds, primarily to provide an early warning of water quality problems (Day and Ewart-Smith 2005). The downstream wetland area (P3d) is inundated on a less frequent basis.
- Overall, the ponds are unnatural water features, and provide a low quality, but locally rare, extent of permanent freshwater habitat, artificially contributing to plant and animal diversity in the area.
- They play an important role in terms of providing a hydraulic barrier for the protection of the greater Atlantis Aquifer from seawater intrusion.

Ad hoc **excavations into the water table**

- These wetlands include P4 and P5 along the internal Duynefontein Road, P6 (west of the existing KNPS) and P7 (immediately south of the existing Koeberg Training Centre).
- Most of the wetlands are reed-dominated systems, providing in the case of at least P6 and P7 and potentially the other systems too, breeding habitat to birds such as Red Bishops and Cape Weavers.
- P6 was probably, prior to the development of the existing KNPS, connected with the mosaic wetland flats and duneslack wetlands described in Section 3.4.2. Today, it exists as an isolated, degraded, permanently saturated wetland.

Association of these wetlands with other wetland types

For the most part, these artificial wetlands occur as isolated wetland habitats, and are not associated with wetland corridors or marginal areas. The exception to this is P7, which lies in the vicinity of the mosaic of seasonal duneslack wetlands, described in Section 2.1.3 and including Sw1 and Sw2. P7 is separated from the wetland mosaic by an access road and areas of mown lawn.

2.1.4 Wetland importance

- ***Ecological importance and sensitivity of seasonally inundated wetlands:*** this measure was calculated, using the assessment protocols outlined in Appendix A, with results being obtained as outlined below:
    - EIS scores for the **seasonally inundated wetlands** within the duneslack mosaic represented by Sw1 and Sw2 as well as their associated seasonally saturated margins, fell within the range of scores associated with a Class A wetland – that is, one of **very high conservation importance.**
    - The **impacted *Ficinia nodosa*** wetland that occurs between the Koeberg NPS and the mosaic wetland area in the south west of the site does not have high conservation importance in its own right, and was assessed as Class D – that is, of **low or marginal importance**. The wetland does however play a potentially important role as a buffer area between the adjacent wetland areas and existing and proposed activities associated with the Koeberg NPS itself.
    - **Seasonally inundated depression** wetlands represented by **Sw3, Sw5 and Sw6** were assessed, in terms of the EIS methodology, as Class B wetlands – that is, of **high conservation importance**, using the criteria listed in Appendix A. It should be noted that these wetlands are presently buffered by relatively narrow fringes of seasonally saturated to moist habitat, and that undeveloped terrestrial areas provide buffering between these isolated systems and activities within the surrounding area. In the case of Sw6, although it has been anthropogenically impacted to a greater extent than the other two wetlands, the habitat type (shallow wetland flats) that occurs there is rarer. Moreover, uncertainty about the faunal communities that occur in the wetland during the wet season force a conservative assessment of its importance in terms of these criteria.
    - **Sw7** was assessed as of moderate to high importance – the wetland is largely unimpacted and the only example of a duneslack wetland in a mobile dune system on the site; nevertheless the wetland is very small, and likely to be spatially temporary, possibly recurring as a wetland type elsewhere in the dunes in the future, as a result of dune dynamics
    - **Sw4** was assessed as **of moderate importance** (Class C) – largely as a result of impacts associated with the adjacent road.

  Together, the seasonally inundated depression wetlands identified on the site are viewed as examples of an important habitat type, and one which is locally rare (in the context of the Duynefontein site and the west coast as a whole) and regionally highly threatened. Seasonally inundated wetland depressions have been significantly impacted by agricultural and urban development, and rough estimates of the impacts to such wetlands in the Cape Metropolitan Area alone suggest that less than 3% of the natural extent of this wetland type may remain intact today (Day 1987 reiterated in Day et al. 2005). The examples that occur on the Duynefontein site are considered to be less impacted than most other examples of this wetland type in the region (Bird 2009).

- ***Importance of artificial, permanently inundated to saturated wetlands***
  The EIS methodology is not considered appropriate for assessing the importance of artificial wetlands, and importance has thus simply been ascribed to these wetlands on the basis of the preceding descriptions:

- **low to moderate conservation importance** for P2, P4, P5, P6 and P7 – these all comprise relatively small areas of seasonally standing water, with little local habitat importance, other than as areas in which dense vegetation affords cover in an otherwise stark portion of land
- **moderate conservation importance** for P1 and P3a-d, based on their provision of (albeit artificial), locally rare, permanent freshwater habitat, which helps to support plant and animal diversity in the area. The infiltration ponds (P3a-d) have additional functional value as hydraulic barriers for the protection of the greater Atlantis Aquifer from seawater intrusion.

2.1.5 Comments on wetland sensitivity

The **seasonally inundated wetland depressions** on the Duynefontein site would be expected to show high sensitivity to sustained changes in hydrological regime and moderate to high sensitivity to changes in water quality, with the latter impacts being magnified by changes in hydroperiod. Over a short (e.g. one to two year) time span, the wetlands would probably be resilient against changes in hydroperiod, since the systems respond to naturally highly variable conditions. The wetlands would, however, show greater sensitivity to <u>increases</u> in hydroperiod, which would be likely to bring about permanent invasion by *Typha capensis* or *Phragmites australis*, than they would to decreases in hydroperiod which would, if occurring on a minor scale, lead to wetland shrinkage but would probably not alter wetland type. Changes in aquatic invertebrate diversity would also be expected in the event that wetland soils no longer dried out during summer, with Day et al. (2009) linking the emergence of several groups of microcrustacean fauna to annual drying of wetland soils.

Permanently inundated to saturated artificial wetlands on the site are expected to exhibit relatively low sensitivity to changes in hydrological regime but a higher sensitivity to changes in water quality. This is because present annual variability in water quality in these systems is probably lower than that in the seasonal systems, already prone to evaporative concentration. Increases in nutrient concentrations in these systems could, for example, result in algal dominance of open waters and a proliferation of reeds in shallow marginal areas.

2.1.6 Description of wetland systems in the vicinity of the Duynefontein site: the Sout River

The Sout River flows into the Atlantic Ocean immediately south of the Koeberg NPS site, within the Melkbosstrand urban area. The river is naturally seasonal but impacted by effluent discharges from the Melkbosstrand WWTW as well as from the Wesfleur WWTW, via the Donkergat River. Such discharges, which were far greater in the past (Day 2007), have resulted in the creation of a dense *Phragmites australis* reedbed in the river reaches downstream of the Melkbosstrand WWTW (immediately upstream of the R27 road bridge). Further downstream, as the river enters the urban area of Melkbosstrand, it is channelised and even canalised in places, and the dense reedbeds give way to an open channel, lined in places by reeds.

This river will not be impacted by activities associated with the proposed Nuclear1 project and is not described in further detail here.

2.1.7 Implications of the baseline wetland assessment for future developments:

Based on the characteristics of the wetlands on the Duynefontein site, the following points should be regarded as important red flags with implications for future development of the site, if this is to avoid significant impacts to wetland systems.

- The seasonal duneslack wetland mosaic in the southern section of the site is regarded as having extremely high biodiversity and hence conservation importance and should be protected from any form of future degradation, or the risk of degradation;
- The isolated seasonal wetlands across the site (e.g. Sw3, Sw5, Sw7) are also regarded as having high conservation importance;
- The artificial wetland P1 should ideally be conserved, and protected from degradation because it provides a locally rare habitat, with relatively unimpacted water quality; and
- Links between all of the above wetlands and broader terrestrial conservation areas should be maintained, so that they do not function as isolated units but play a role in landscape-level ecosystem processes.

Protection of the above systems requires that:

- The groundwater systems on which these wetlands rely remain intact, and there is no change in the quality, timing or magnitude of water supply to these wetlands;
- There is no change in the resilience of groundwater systems to continue to support the identified wetlands – that is, groundwater systems should not be stressed to a level where it becomes likely that in times of water stress they will no longer be able to meet ecosystems demands that are currently quite adequately, even in times of drought;
- Supporting ecosystems (e.g. surrounding terrestrial areas) should be actively conserved, so that corridors between habitats are protected;
- Ongoing efforts are applied to the removal of alien vegetation;
- In the case of Sw7, and other similar wetlands that are likely to recur in the dunes over time, the maintenance of the mobile dunes as dynamic dune systems is required, if these habitats are to be sustained; and
- Adequate setbacks are set in place, over and above those required to ensure the above requirements, to allow for physical separation of developed areas from conservation areas. **It must be stressed however that surface setbacks on their own will not provide protection for the groundwater-fed systems.**

The artificial wetlands (P2 to P7) are all of functional importance, but are considered replaceable within the broader area. The replaceability of the function of the recharge ponds in the north of the site (P3a-d) would need to be considered carefully, as continuation of this function depends on the availability of adequate areas of recharge elsewhere and on distance from other aquifer users. Moreover, the degree to which the role of these wetlands in providing a hydraulic barrier to seawater intrusion into the aquifer is necessary and/or site-specific may also require consideration.

2.2 Bantamsklip

2.2.1 Site context and overview

The Bantamsklip site (Figures 2.3 and 2.4) lies on the western side of the Agulhas Plain, which extends from the Klein River mouth to the Breede River, covering an area of some 270,000 ha and separated from the interior plains of the Overberg by the almost continuous Kleinrivier-Heuningberg Mountains in the West and Tertiary hardened dunes and Potberg Mountain in the East. The Agulhas Plain as a whole constitutes one of the largest extant storehouses of lowland fynbos and Renosterveld habitats in the world and the diversity of habitat types, wetland ecosystems, red data plant species and local endemics found in this area are unmatched in the Cape Floristic Region (Jones *et al.* 2002).

The inland waters of the Agulhas Plain area comprise a wide diversity of systems, ranging from saline to fresh, and its diverse wetland ecosystems include coastal lakes, floodplains, valley bottom wetlands and rivers. Conservation of the Agulhas Plain area as a whole has been strongly recommended (Jones *et al.* 2002). The Bantamsklip site itself has been identified as a particular floral conservation priority by a number of studies, including Rebelo and Sigfried (1992), Willis *et al*. (1996) and Cowling (1996), who described the site as harbouring some 800 plant species, including 21 Agulhas Plain endemics, six of which are virtually entirely restricted to the Bantamsklip Farm. Most of the floral endemics occur on the limestone formations (Cowling 1996), and are terrestrial, rather than wetland associated.

In terms of wetlands, the Bantamsklip site can usefully be divided into two portions – the area north of the R43 road and the area to the south. The former includes portions of the Groot Hagelkraal River system (Figure 2.4) as well as extensive hillslope seeps and valley bottom wetlands which contribute to this system. The eastern boundary of the site is formed by the naturally occurring surface drainage boundary between the Groot Hagelkraal and Koks Rivers (SRK 2009). The Koks River flows eastward and joins the important Ratels River system, while the Groot Hagelkraal River (also called the Groot Haelkraal River in some reports (see Day 2005)) flows westwards, with an extensive portion of this river and its tributaries and hillslope seeps being included in the Eskom site (Figure 2.4).

The portion of the Bantamsklip site to the south of the R43 lies outside of the Groot Hagelkraal River catchment. The site assessments in this portion found no wetland systems, other than the marine shores themselves – a wetland type excluded from this study. A single small patch of vegetation in the west of the site, at the toe of a limestone outcrop, supported patchy *Ficinia nodosa* sedge – a species that is associated with the transitional margins of many seasonal wetlands in the Western Cape. In the present case, however, the small patch was not associated with any other indicators of wetter conditions, and is noted for interest only in this section. Its position is indicated in Figure 2.4.

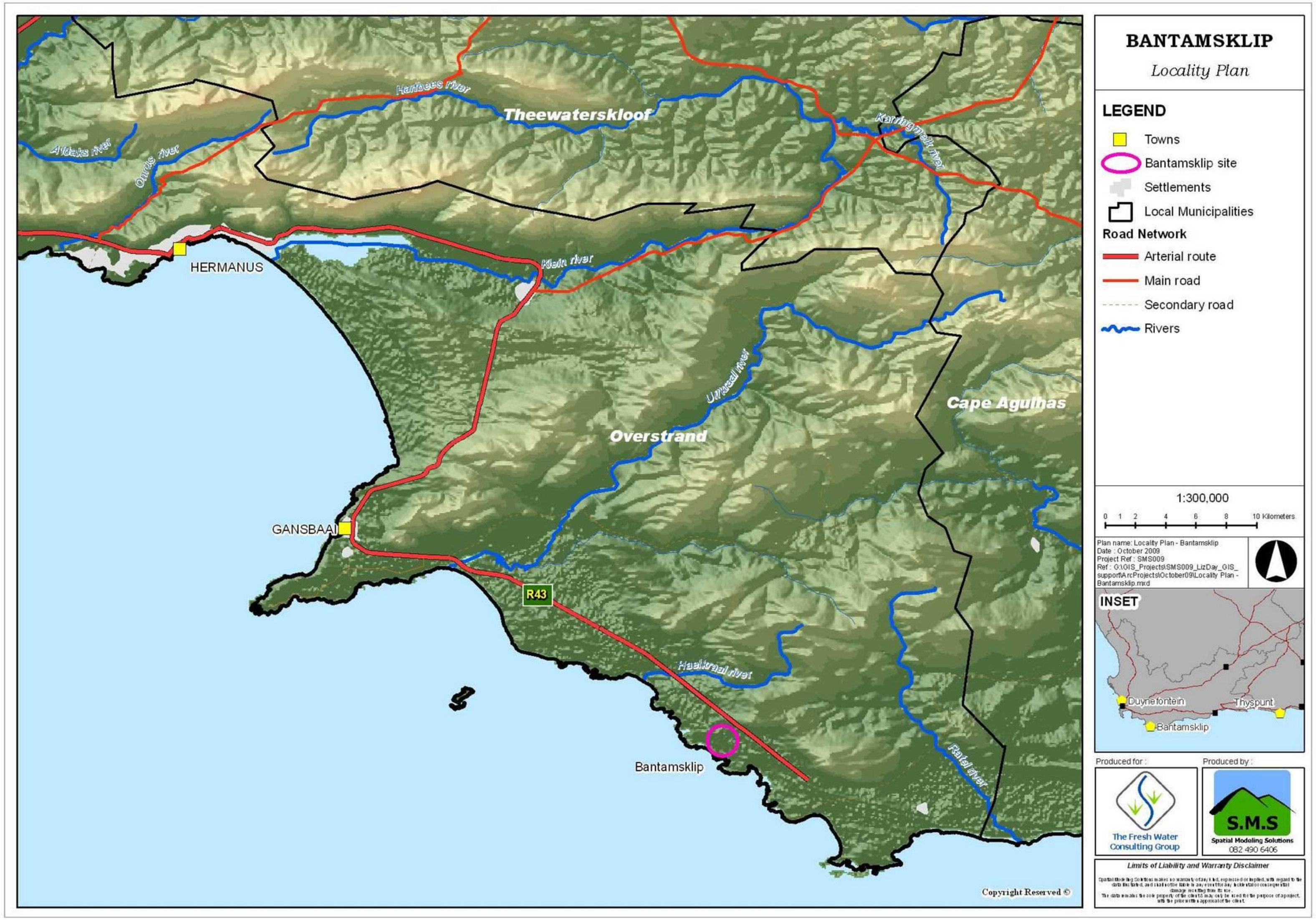


Figure 2.3 Site context of Bantamsklip

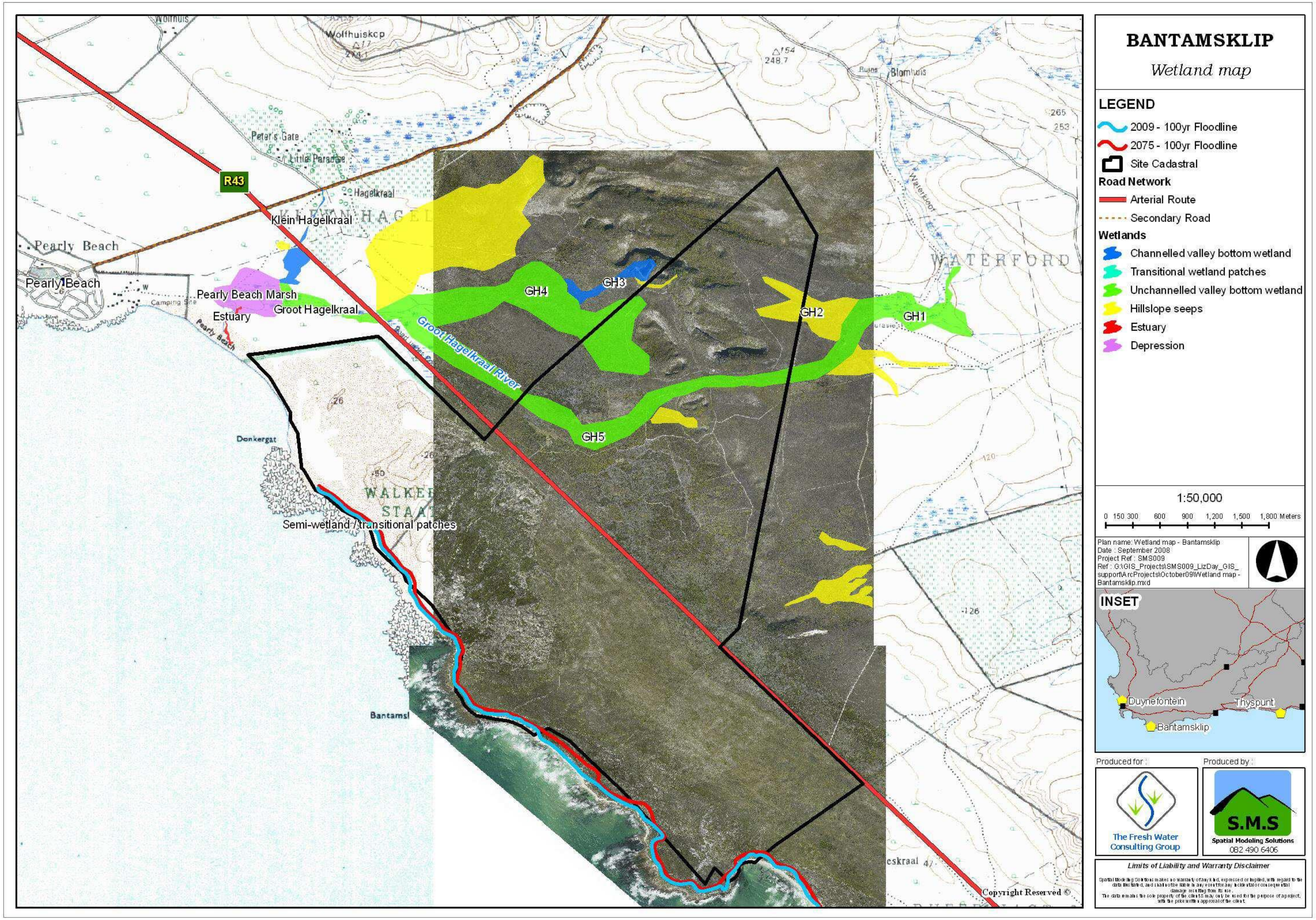


Figure 2.4 Location of wetlands identified on the Bantamsklip site.

2.2.2 Description of the Groot Hagelkraal wetlands

The Groot Hagelkraal River flows as an unchannelled valley bottom wetland, as far as its confluence with the channelised Klein Hagelkraal River, downstream of the R43 road (Figure 2.4). Shortly downstream of this confluence, the river broadens out, forming a wide, coastal lake, referred to by Jones *et al.* (2002) as the Pearly Beach Marsh. The coastal lake narrows into a wide, slow-flowing river, which opens into a shallow lagoon, on Pearly Beach (Figure 2.4). The Groot Hagelkraal River downstream of the R43 lies outside of the Bantamsklip site boundary, but would potentially be affected by activities within its upstream catchment area. Day (1989) described the site as unique in terms of its wetland systems, and recommended its protection as a Site of Special Scientific Interest.

Water quality and aquatic invertebrate samples were collected from various sample points in the wetlands on the site. These data are presented in Tables 2.4 and 2.5, and discussed in the relevant sections below.

Table 2.4 Water quality in sampled wetland sites at Bantamsklip, all from the Groot Hagelkraal wetland system

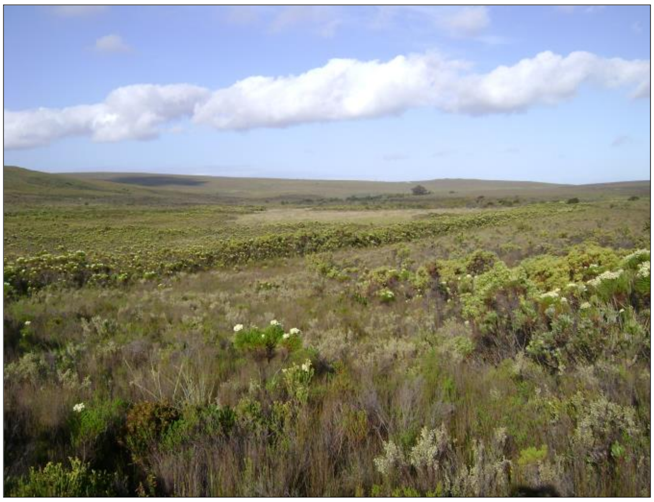
Samples collected in September 2007. Sites as shown in Figure 2.4.

Sample	**NO_3+NO_2-N** µg/L	**NH_4-N** µg/L	**Ortho-P (PO_4-P)** in µg/L	**Total P** in µg/L	**pH**	**EC** mS/m
GH2	-	-	-	-	*6.45*	*40.4*
GH3	*61*	*250*	*<25*	*<25*	*7.55*	*51.4*
GH4	*<25*	*74*	*106*	*486*	*6.65*	*39.5*
GH5	*29*	*85*	*<25*	*<25*	*6.01*	*38.3*

Figure 2.4 provides a broad-scale overview of the extent of wetlands on and adjacent to the site[4]. The main stem of the Groot Hagelkraal River enters the site from the north east, flowing within a well-defined but unchannelled valley bottom, densely vegetated across the wetted base by Palmiet reeds (*Prionium serratum*) (GH1 in Figure 2.4), which give way to a longitudinal band of at least seasonally saturated wetland, dominated by mixed *Berzelia* spp. and *Psoralea* spp.

[4] Note that the terms of reference for this project did not allow delineation of wetlands at the Bantamsklip site to a high level of accuracy – wetland polygons have been digitised based on limited ground truthing, aerial photography and existing wetland delineations (e.g. Cole *et al* 2000)

Description of hillslope seeps and minor tributaries of the Groot Hagelkraal system



<u>Photo B-a</u>
Hillside seep (GH2 in Figure 2.4) feeding into the Groot Hagelkraal River to the east

A large hillslope seep within the Bantamsklip site boundary feeds towards the river in a south easterly direction (Photo B_a and GH2 in Figure 2.4). The upper and marginal areas of the seep are characterised by the dense plant community typical of wetlands in the Groot Hagelkraal system on the site, and described by Cowling (1996) as dominated by *Berzelia* spp., *Psoralea* spp., *Leucadendron salicifolium* and *Osmitopsis astericoides*. Within the hillslope seep, however, occasional low lying depressions have formed, varying in size between a few metres wide and one extensive depression, vegetated by dense sedges, including *Neesenbeckia punctoria* and *Carpha glomerata* (B. Low, COASTEC, pers. comm.). These depressions are inundated with water in winter and in some cases up to early summer, and provide mildly acidic (Table 2.4), habitat for several species of frogs, as well as other wetland fauna. Harrison *et al*. (2009) noted that the critically endangered Micro Frog *Microbatrachella capensis,* the endangered Cape Platanna *Xenopus gilli* and the Western Leopard Toad *Amietophrynus pantherinus* all occur in and around these and other standing water wetlands within the Groot Hagelkraal system.

Photo B-b
Small impoundment in GH3, feeding into Groot Hagelkraal west of the Bantamsklip site

Numerous other seeps extend down the western slopes of the hillside, feeding into other valley bottom systems associated with the Groot Hagelkraal wetlands as a whole. One of the larger of these valley bottom wetlands emerges at the foot of the limestone hills on the north eastern boundary of the site (GH3 in Figure 2.4) just outside the site boundary. The wetland is fed by perennial springs that daylight as small streams in the dense coastal forest in the limestone hills above. Downstream of the forest the stream is impounded, and forms a shallow area of standing water

(Photo B-b), which was sampled for both water quality and aquatic invertebrates (GH3 in Tables 2.4 and 2.5).

The water quality sample indicated low concentrations of phosphorus in the water (< 0.005 mg P/l), suggesting that the water body is oligotrophic with respect to phosphorus (DWAF 2002). Nitrogen nutrients, including total ammonia concentrations, were higher than measured elsewhere on the site, but remained within DWAF's (1996) range for oligotrophic conditions (Table 2.2).

The dam provides habitat for frogs, including, potentially, the endangered species listed above. Specimens of the indigenous fish *Galaxias zebratus* (Cape galaxias) were also found in the dam, and are assumed to occur elsewhere on the site.

Emergent reeds form dense stands in the dam shallows and permanently inundated wetlands in the upstream extent of the impoundment. These comprise mainly patches of *Typha capensis* and dense stands of *Pennisetum macrourum*. The inundated dam margins along the southern margins give way to the typical *Berzelia / Psoralea* wetland communities, which form an almost continual swathe along the dam. These merge with wide bands of south westerly flowing hillslope seeps, which extend down the adjacent slopes.

Downstream of the dam, the naturally unchanelled valley bottom has been channelled – possibly as a result of receipt of concentrated flow from the dam's spillway channel. With distance downstream, however, it appears to widen out once more, forming the extensive unchannelled valley bottom wetland flats that characterise the Groot Hagelkraal wetlands to the north and west of the site boundary.

Description of the main stem of the Groot Hagelkraal River

<u>Photo B_c</u>
Portion of braided Groot Hagelkraal at GH5, on the Bantamsklip site.

The main stem of the Groot Hagelkraal River flows within a broad, braided swathe along the southern portion of the site, north of the R43 (Photo B_c and GH1 and GH5 in Figure 2.4). As the wetland widens out, the dense Palmiet beds of the upstream reaches give way to wide swathes of a mixed wetland community, dominated on its drier, outer edges by terrestrial and transitional wetland species, including *Elegia tectorum*, *Rhus* spp., and *Metalasia muricata*, while wetter patches comprise mixed *Psoralea / Berzelia* (*Psoralea pinnata, Psoralea afila and Berzelia* spp.) communities.

The braided wetland channels of the Groot Hagelkraal itself are edged with a dense overgrowth, including *Zantedeschia aethiopica* (arum lilies), *Juncus capensis*, and *Scirpus nodosus.* These give way along their margins to the *Berzelia – Psoralea* communities that characterise most of the wetlands on the site, as well as to stands of *Pteridium aquilinum* (bracken fern). Within these reaches (GH5 in Figure 2.4), past and present activities on the site have resulted in clear signs of disturbance to the wetlands. Access roads across the wetlands have resulted in local channelisation and constriction of flows. Portions of the site appear to have been ploughed or cleared in the past and invasion by alien woody vegetation has been extensive. Large areas in this portion of the site have been cleared of these aliens, but remain disturbed, and presently colonised by pioneer indigenous vegetation such as *Metalasia muricata* and by pioneers such as *Pteridium aquilinum* (along and within wetland areas).

The start of minor head-cut erosion in the channelised wetland downstream of the road crossing at GH5 was noted with concern at the time of the site visit, as such head cuts can quickly worsen, and spread through whole systems.

Water quality in this section of the Groot Hagelkraal system indicated the persistence of a mildly acidic wetland that appears to be oligotrophic with respect to both phosphorus and nitrogen nutrients (Table 2.4) and as such probably fairly typical of the kinds of conditions in which *Berzelia* spp. usually occur.

Despite ongoing alien clearing, invasion by alien vegetation becomes the dominant impact to the wetland systems with distance downstream, resulting in drying out of seepage areas, reducing flows through the system, increasing the likelihood of channelisation and erosion and reducing habitat quality.

The Groot Hagelkraal River downstream of the R43 and the Eskom site

The broad swathes of valley bottom wetland comprising the Groot Hagelkraal River system are channelled beneath the R43 road, resulting in considerable narrowing of the wetland, and concentration of its flows into a defined channel. The channel gives way in places to remnant patches of mosaic seasonal wetlands, which were probably once linked to the river during flood periods and correspond to the saltmarsh/wetland described by Euston-Brown (2003). Alien vegetation (mainly *Acacia saligna* thicket) in the vicinity of the river channel remains extensive, making mapping of the Klein Hagelkraal and Groot Hagelkraal River confluence difficult and undoubtedly reducing the extent of functional wetland in this area.

Some 50 - 70m downstream of the R43, the river opens into a wide, in-channel depressional wetland, edged by low-growing sedge marsh wetland and referred to by Jones *et al*. (2002) as the Pearly Beach Marsh. Plant zonation within the marsh is strongly influenced by topographic differences, with the slightly higher outer expanse of the wetland being dominated by dense *Scirpus nodosus* sedges, while the lower-lying, open water habitat includes patches of *Schoenoplectus scirpoideus* and scattered *Typha capensis,* with *Isolepis prolifer* in the shallow margins.

The limited growth of *T. capensis* in the marsh, coupled with clear open waters, an absence of alien aquatic macrophytes and low levels of filamentous and floating algae suggest that the marsh remains a relatively unimpacted, oligotrophic system. Day (2004) described the wetland as providing habitat to a large diversity of wetland-associated fauna, including mongooses, otters, African Fish Eagle, numerous passerine birds and waterfowl. The presence of these larger wetland animals suggests that the wetland also supports a diverse and abundant community of smaller animals, such as fish,

Photo B-d
Wetland habitat at Pearly Beach estuary – west of the Bantamsklip site

macroinvertebrates and zooplankton. Jones *et al*. (2002) described it as an extremely important wetland habitat, while Euston-Brown (2003) classified it as of high regional and local importance, from a botanical perspective.

The Pearly Beach Marsh opens periodically to discharge flow across Pearly Beach, via a small estuarine wetland or coastal lagoon (Photo B_d).

2.2.3 Aquatic invertebrate fauna

Aquatic invertebrates were sampled in the wetlands of the Groot Hagelkraal system where standing water habitat was available. It should be noted that although the wetland areas themselves are extensive, standing water habitat is fairly limited, with most systems comprising shallow trickle flow or subsurface seepage. Invertebrate samples showed a relatively low diversity, when compared with aquatic invertebrate diversity at the other two proposed NPS sites, and no zooplankton fauna were found in either of the sampled Bantamsklip sites. Ironically, since this was the only artificial habitat sampled, GH3 (the impoundment immediately downstream of the forest seep) showed the greatest invertebrate diversity, with 19 different taxa identified. Most of these were non-biting and biting midges (chironomids and ceratopogonids) and the invertebrate community was generally typical of permanent, standing water habitat. Beetles of the genera *Paracymus* and Hydraena (Table 2.5) occurred at this site only – these are locally common but considered probable southern African endemics (Stals and de Moor 2007). Low numbers of mayflies (*Cloeon* sp. and *Caenis* sp.), both typical of slow flow or standing water areas, also occurred at this site. Two common libellulid and coenagrionid dragonfly and damselfly taxa were identified, both also typical of pool or wetland conditions, where they occur in overhanging or aquatic vegetation.

By contrast to the invertebrate community sampled at GH3, the invertebrate community in the braided channel of the Groot Hagelkraal wetland at GH5 had closer affinities to riverine invertebrate communities. Freshwater amphipods were relatively abundant at the site. Of the two species identified, *Paramelita capensis* is a widespread Western Cape endemic while *Paramelita validicornis* has been more specifically recorded from the south coast region between Hermanus and Bredasdorp (Griffiths and Stewart 2001). The coleopteran taxa in this system are all from endemic genera. *Gyrinus vicinus* has been recorded from still water ranging from fresh to brackish conditions in lowland regions of the Western and Eastern Cape. The dryopid genus *Rapnus* sp. has been recorded in only the Western and Eastern Cape and is endemic to southern Africa (Stals and de Moor 2007). Simulid dipterans, the ephemeropteran mayfly *Pseudocloeon* sp. and the four trichopteran taxa identified are all indicative of flowing riverine conditions, while the caddisflies *Dolophilodes forcipatus* and *Leptecho* sp. that also occurred at this site are known to have a distribution limited to the southern Cape (de Moor and Scott 2003).

Table 2.5 Invertebrate taxa from wetland sites at Bantamsklip

All samples collected from the Groot Hagelkraal wetland system. Samples collected in September 2007. Taxa organised by major groups, taxonomic order, family and then species. Taxa with "?" denotes an uncertainty of species designation, "c.f." means that taxon keyed out to this point in the taxonomic reference used (typically a key from another region of the world) and although this is the closest designation, the specimen may or may not be within this genus. Abundance ratings on log scale as follows: A = 1, B = 2-10, C = 11-20, D = 21-100, E >100. Samples at GH5 separated into habitat types – MVEG=marginal vegetation; SIC=stones-in-current habitat,

Order	Family	Taxon	Common Name	GH5 MVEG	GH5 SIC	GH3 (dam)
Amphipoda	Paramelitidae	*Paramelita capensis*	scuds, sideswimmers	C	B	
		Paramelita validicornis			A	
Oribatida	Oribatidae	Oribatidae spp.	soil mites			D
Coleoptera	Dryopidae	*Rapnus* sp. adult	long-toes water beetles	A		
	Elmidae: Elminae	c.f. *Gonielmis* sp. larvae	riffle beetles		C	
	Gyrinidae: Gyrininae	*Gyrinus vicinus* adult	whirligig beetles	B		
		Gyrinus vicinus larvae		A	A	
	Hydraenidae: Hydraeninae	*Hydraena* sp. larvae	minute moss beetles			A
	Hydrophilidae: Hydrophilinae	*Paracymus* sp. larvae	water scavenger beetles			B
Diptera	Ceratopogonidae: Ceratopogoninae	*Bezzia* sp. larvae	biting midges, no-see-ums			B
		Bezzia sp. pupae				B
	Ceratopogonidae: Dasyheleinae	*Dasyhelea* sp. larvae				B
		Dasyhelea sp. pupae				B
	Chironomidae: Chironominae	*Polypedilum* sp. larvae	non-biting midges			A
		Tanytarsus sp. larvae				C
		Zavrelliella sp. pupae				A
	Chironomidae: Orthocladiinae	*Cricotopus* sp. larvae				B
		Rheocricotopus sp. larvae			B	B
	Chironomidae: Tanypodinae	*Clinotanypus* sp. larvae			A	

Order	Family	Taxon	Common Name	GH5 MVEG	GH5 SIC	GH3 (dam)
		Larsia sp. larvae				B
	Culicidae	Culicidae sp. adult	mosquitoes	A	C	B
	Simuliidae	*Simulium (Nevermannia)* sp. larvae	blackflies	B	B	
		Simulium sp. adult		A		A
Ephemeroptera	Baetidae	*Cloeon* sp.	minnow mayflies			B
		Pseudocloeon/Labiobaetis sp.		B	B	
	Caenidae	*Caenis* sp.	cainflies			B
Hemiptera	Gerridae: Gerrinae	*Limnogonus* c.f. *capensis*	water striders, pond skaters	B		
Odonata: Anisoptera	Libellulidae	*Olpogastra fuelleborni*?	darter dragonflies			B
Odonata: Zygoptera	Coenagrionidae	*Ischnura senegalensis*	blue damselflies			B
		Pseudagrion sp.	sprite damselflies	B		
Trichoptera	Hydropsychidae	*Cheumatopsyche maculata*	fixed shelter caddisflies		C	
	Philopotamidae	*Dolophilodes forcipatus*?	net maker caddisflies		A	
	Hydroptilidae	*Oxyethira velocipes*	purse-case maker caddisflies			B
	Leptoceridae	*Leptecho* sp.	transportable case maker	B	B	
			Total number	**10**	**12**	**19**

2.2.4 Assessment of Present Ecological Status (PES) of wetlands on the Bantamsklip site

The Groot Hagelkraal wetlands were assessed using two different PES methodologies – WET-Health (Level 2) (see Appendix C) and the PES methodology as outlined by DWAF (1999) and described in Appendix D.

The PES methodology as described by DWAF (1999) was used to derive an overall PES score for the Groot Hagelkraal system as a whole, upstream of the R43. By contrast, the WET-Health methodology was used to provide a more detailed assessment of the major valley bottom wetlands of the system, using two of the three assessment modules, namely the hydrological and vegetation assessment modules.

<u>WET-Health assessment</u>

Two HGM units were assessed for the Groot Hagelkraal system, namely GH1 and GH5 (Figure 2.4), which cover areas of approximately 90.4 and 58.9 hectares respectively. GH1 comprises a largely unimpacted area, with little alien vegetation cover. GH5, by contrast, is subject to fairly intensive alien vegetation invasion in places, and has been impacted by past agricultural activities.

Assessment of the HGM units in terms of the WET-Health hydrology module resulted in an allocation of a Health Category A for GH1, indicating a system that is "unmodified or natural" with respect to its hydrology. The only aspects that were actually allocated impact scores were those linked to minor invasion of the HGM unit by woody alien vegetation, which potentially reduced water quantities within and through the HGM unit. The mean "Intensity of impact" score for the system was 0.

The Vegetation Module also resulted in an allocation of a Health Category of A to this HGM unit, based on the presence of largely undisturbed natural vegetation in this unit.

GH5, downstream of GH1, by contrast, was accorded a Health Category of C (moderately modified) with respect to hydrology. The major factors impacting on wetland hydrology related to the presence of extensive woody alien vegetation in the lower reaches of this HGM unit, affecting water quantity as well as to minor impacts in the form of low levels of abstraction and the presence of road crossings across the wetland.

The Vegetation Module similarly accorded a Health Category C to HGM unit GH5, with the main impacts in terms of vegetation being those resulting from alien vegetation and past agricultural disturbance.

A combined WET-Health category B (largely natural with few modifications and a slight change in ecosystem processes) was accorded to the wetland as a whole for both the Vegetation and the Hydrology modules, taking into account the relative hydrological "health" or integrity of the two HGM units.

<u>PES using DWAF (1999) methodology</u>

The PES methodology was used to derive a simplified, overview assessment of wetland Present Ecological Status, for each of the wetland types identified on and associated with the Bantamsklip site. This assessment is considered complementary to the WET-Health assessments of selected HGM units within the wetlands. Using the protocol outlined in Appendix D, the wetlands were scored high (4 – largely unmodified) in terms of water quality modifications, faunal and aquatic floral changes. Moderate modifications in terms of flow and terrestrial encroachment patterns were noted (scored as 2), while hydraulic criteria such as canalisation were scored 4 (not in evidence). Hydraulic change and habitat fragmentation as a result of roads and bridges were scored as 2.5 (moderately modified) in recognition of fragmentation as a result of roads.

The mean of these scores was used to place the wetland in a PES Category, which in the case of the Groot Hagelkraal system, between its source area and the estuary, was assessed as of a **PES category B**. It should be noted that this assessment in no way contradicts the outcome of the WET-Health assessment – the latter was designed so as to separate out discrete wetland units in terms of impacts.

2.2.5 Comments on wetland sensitivity

The wetlands on the Bantamsklip site are considered highly sensitive to changes in water quality (particularly changes in pH, salinity and nutrient concentrations), any of which could impact on the plant communities that provide the basic structure for and underpin the function of the wetlands. The wetlands are also considered vulnerable to physical disturbance, particularly any disturbance that results in concentrations of flow into downstream areas, impoundment and increased vulnerability to alien invasion as a result of clearing or exposure of open substrate.

Decreases in flow (e.g. as a result of increased surface or groundwater abstraction) would also potentially impact on the wetland systems which, at least for the portion of the Bantamsklip site north of the R43, are already impacted by abstraction and the effects of alien invasion on water availability. Decreases in flow would result in wetland shrinkage and loss of relatively rare open water wetland habitat types such as seasonal, shallowly inundated standing water pools.

Of the different wetland types identified on and associated with the site, the unchannelled valley bottom wetlands would be most resilient against moderate impacts in terms of water quality, while hillslope seeps would be vulnerable to water quality impacts and, in particular, to physical disturbance. All of the wetlands assessed would be sensitive to physical disturbance, particularly where it increased the likelihood of impacts such as head cut erosion through the systems.

In addition to the wetlands on the Bantamsklip site itself, it is also noted that the Pearly Beach Marsh coastal lake downstream of the site is considered of high conservation status (Section 2.2.2) and would be affected by changes in flow or water quality that occurred in its catchment. The wetland is considered particularly sensitive to sedimentation as well as nutrient enrichment, which could lead to long term nutrient loading, with little possibility of flushing (Day 2004).

Finally, the Groot Hagelkraal system as a whole should be considered sensitive to impacts such as fragmentation, which would reduce connectivity between the relatively unimpacted high lying source areas of the system, within the Bantamsklip site and beyond, and its estuary on the beach. The system is already fragmented by the R43. Increases in the use of this road would create a greater barrier to faunal movement and increase reliance for connectivity on the limited culverts beneath the road.

2.2.6 Assessment of Wetland Ecological Importance and Sensitivity (EIS)

Using the EIS protocol outlined in Section 1.4.5, and based on the comments provided in Section 2.2.5, importance and sensitivity classes were assigned to wetlands on the Bantamsklip site, which were evaluated together as an integrated wetland system as of

high importance (Wetland Importance Class B). This assignment of importance was driven largely by the fact that the wetlands:

- support populations of rare or endangered faunal species (e.g. Micro Frog, Western Leopard Toad);
- contain areas of particular habitat and/or species richness (the wetlands as a whole include a wide diversity of habitat types, including hillslope seeps, coastal forest seeps, extensive valley bottom wetlands, a coastal lake and an estuarine salt marsh);
- contain habitat suitable for specific wetland species (e.g. large wetland expanses suitable for small and medium wetland-associated mammals such as otters; feeding grounds for African fish eagles; breeding habitat for microfrogs and other frogs; invertebrate habitat);
- provide unique habitat types (e.g. the Pearly Beach Marsh);
- are sensitive to changes in hydrology, patterns of inundation, discharge rates, water quality and/or human disturbance; and
- are important for conservation, education and potentially for eco-tourism (they would lend themselves to the development of low-impact hiking trails).

2.2.7 Implications of the baseline wetland assessment for future developments:

Based on the characteristics of the wetlands on the Bantamsklip site, the following points should be regarded as important red flags with implications for future development of the site, if this is to avoid significant impacts to wetland systems:

- The valley bottom wetlands and hillslope seeps of the Groot Hagelkraal River should be regarded as of high sensitivity and high conservation importance, and should be protected from any form of future degradation, or the risk of degradation; and
- The Pearly Beach Marsh and the Groot Hagelkraal estuary should be protected from any form of future degradation, or the risk of degradation.

Protection of the above systems requires that:

- There should be no changes in the quality, timing or magnitude of water supply from surface or groundwater flows supporting these systems;
- Supporting ecosystems (e.g. surrounding terrestrial areas) should be actively conserved, maintaining links between the wetlands and the adjacent mountains and coastal areas; and
- Adequate setbacks should be set in place, over and above those required to ensure the above requirements, to allow for physical separation of developed areas from conservation areas, to reduce impacts such as noise, human activity and the spread of weedy or other alien plant material into these wetlands, and to maintain corridor function along river systems.

2.3 Thyspunt

The increased level of detail supplied in this section on the Thyspunt location, and a somewhat different template for description of the different wetlands on and associated with the site resulted from consideration of the complexity of the site, both in terms of the number and variety of wetlands, and in terms of the complexity of hydrological and geomorphological functioning of these wetlands, both individually and at a landscape level.

2.3.1 Site context and overview

The Thyspunt site lies in the Eastern Cape, between Cape St. Francis (to the east) and Oyster Bay (to the west) (Figure 2.5). The topography of the site is dominated by west–east orientated dune systems running broadly parallel with the coast.

The first of these, closest to the coast, comprise relatively low lying (mainly less than 20m amsl) densely vegetated stable dunes. Inland (north) of these are two largely unvegetated mobile dune systems: an extensive line of tall (up to 100m amsl – SRK (2009)) dunes, referred to by Illenberger (2009) as the Oyster Bay dunefield, and a second line of more southerly mobile transverse dunes, east of the Eskom site boundary, referred to by Illenberger (2009) as the Thysbaai Dunefield (Figure 2.6). Both these mobile dunes are so-called headland bypass dune systems, and are described by Illenberger (2009) as the last two remaining examples of active large-scale mobile headland-bypass dunefields on the south coast of South Africa.

Invasion by woody alien vegetation is extensive across the site, and particularly in the area between the parallel dune systems, resulting in stabilisation of large areas of the dunefields (Illenberger 2009).

The mobile dunefields are associated with extensive wetlands, which occur in the interdune "slack" areas. The eastern quarter of the Oyster Bay dunefield drains into the Sand River – an "episodic" river, which comprises largely shallow subsurface flow, save during flood episodes, when it carries runoff and subsurface flow from the dunes and surrounding farmland and other developed areas into the Krom River. La Cock and Burkinshaw (1996) note that the Sand River has, over the last 200 years, migrated between St. Francis Bay and a point some 4km upstream of the mouth of the Krom River. These authors and others familiar with the site, including FCG, consider the Sand River system within the dunes and the broad matrix of wetlands with which it is linked between the dune field and the sea to be a unique feature, and one of a kind. Local conservation groups are in the process of compiling an application for the system's declaration as a Ramsar wetland site.

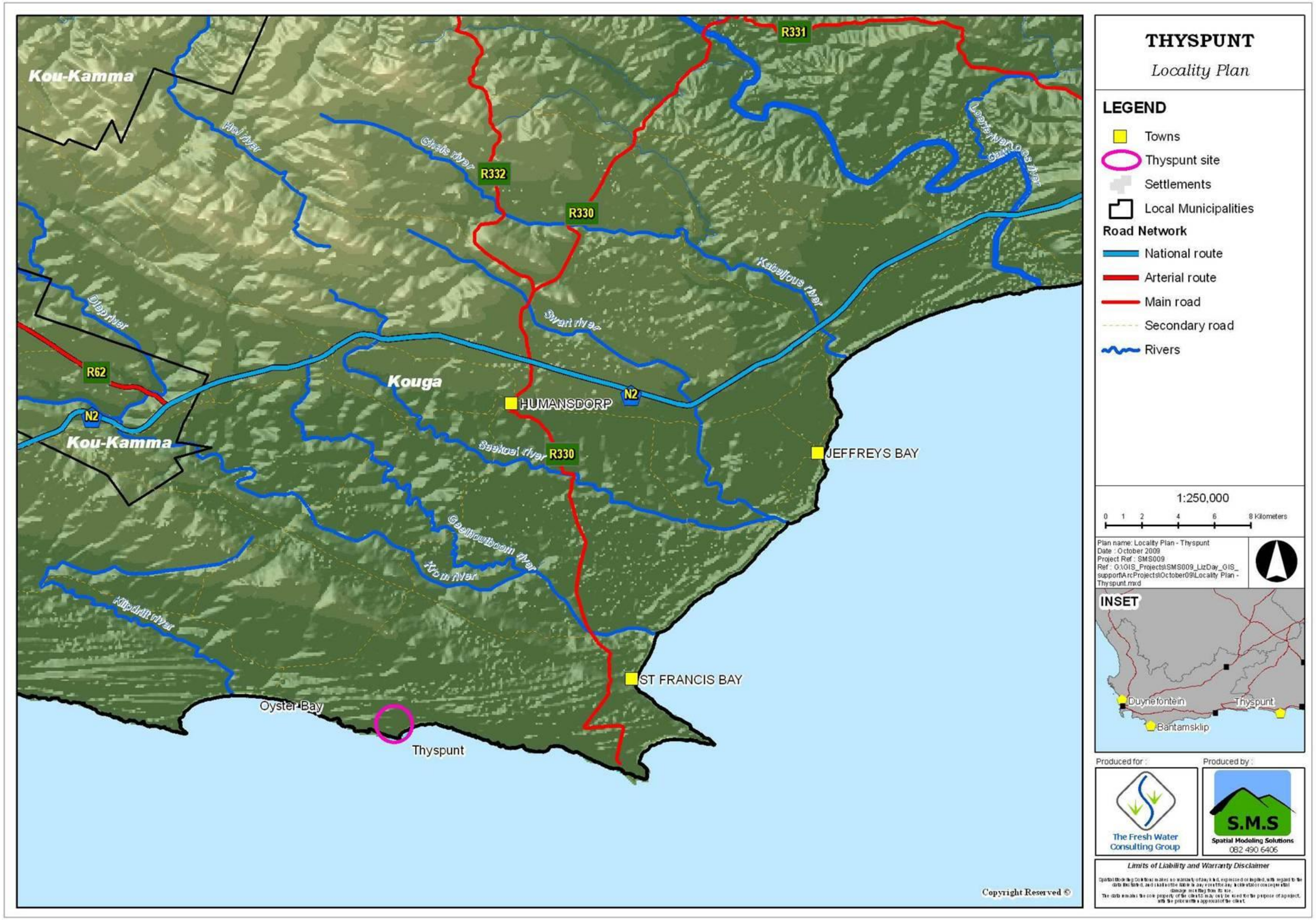


Figure 2.5 The Thyspunt site in the context of Oyster Bay and Cape St. Francis

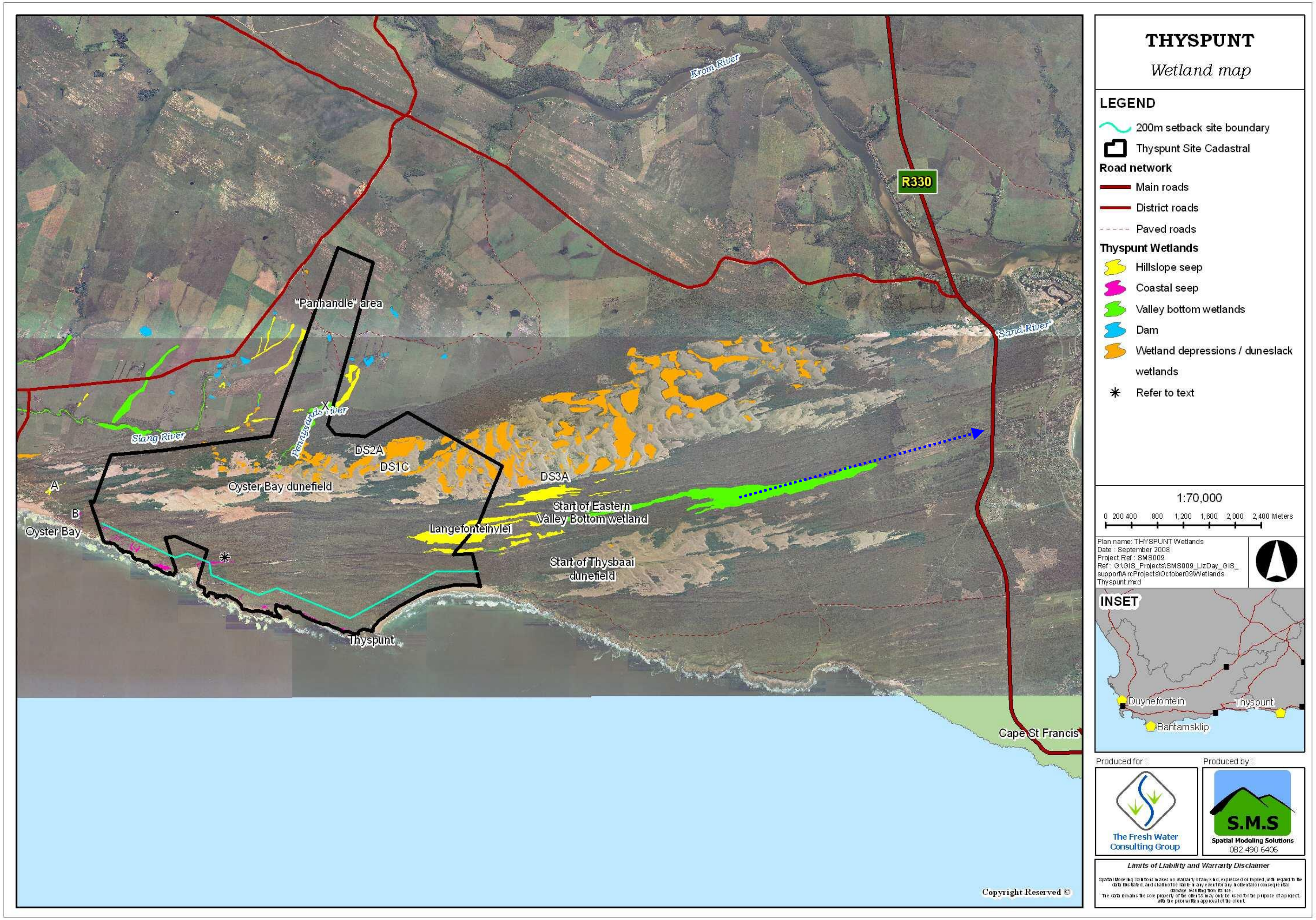


Figure 2.6 **Wetlands on the Thyspunt site and immediate surrounds, showing mapped wetland areas.** Two lines of mobile transverse dunes are clearly visible in the aerial photograph, with the more southerly line (the Thysbaai dunefield) lying largely to the east of the site, and the larger Oyster Bay dunefield, which includes the Sand River system, extending from Oyster Bay almost to St Francis Bay. Wetland extent not based on a detailed wetland delineation. Note that wetland extent in the Oyster Bay dunefields changes constantly, with the movement of the mobile dunes and fluctuations in surface and groundwater availability. Blue arrow indicates direction of flow of Eastern Valley Bottom wetland.

2.3.2 Rainfall

The site receives between 600 and 900 mm rainfall per year (Illenberger 2009), most of which occurs during the winter, although in fact heavy rainfalls can occur throughout the year.

2.3.3 Surface Hydrology

The western portion of the site lies within quaternary catchment K80F, drained by the Slang and Klipdrif Rivers. The north and eastern portions of the site lie within quaternaries K90D and K90E, draining via the Sand River into the Krom River (Figure 2.6).

The Slang River is the only other major river that is associated with the Thyspunt site, draining into the sea immediately west of Oyster Bay Village. This river receives runoff from valley bottom and hillslope seep wetlands in the northern “panhandle” portion of the owner-controlled Eskom site (Figure 2.6), and flows immediately north of the Oyster Bay dunefield as a channelised, increasingly disturbed valley bottom wetland.

In addition to these relatively major river systems, a number of unnamed but nevertheless significant drainage lines occur on and near the site. The dominant systems comprise:

- An unchannelled valley bottom wetland (referred to in this report as the “Eastern Valley Bottom wetland”), which drains the area between the two mobile dune systems, east of the Eskom site boundary flowing from a point just east of the Langefonteinvlei, towards St. Francis Bay. This system has been highly invaded by woody alien vegetation. Its downstream extent is subject to increasing levels of development, passing through proposed and recently constructed resort developments (e.g. the Dunes) and then The Links Golf Course Estate, where it was diverted in the past via a channel into the Sand River to the north. This measure facilitated downstream development across much of its natural alignment (La Cock and Burkinshaw 1996). The long-term dangers of such mis-management of drainage systems was illustrated during December 2007, when heavy rainfall resulted in flooding of The Links golf course, and the passage of water and sediment down the natural flow path of this valley bottom wetland, causing extensive destruction in the town of St. Francis Bay. Re-diversion of the channel immediately upstream of The Links is proposed as one of a number of means of preventing a recurrence of flood damage.
- A naturally channelled valley bottom wetland on the north of the site, which dissipates into the dunefield within the Pennysands Farm boundary. This wetland is referred to in Illenberger (2009) as the Pennysands River.

In addition to the valley bottom wetlands listed above, numerous hillslope seeps and depressional wetlands also occur throughout the site. These and the valley bottom wetlands are all described in more detail in Section 2.3.7, in terms of their biophysical attributes, their conservation importance, and their major system drivers.

2.3.4 Geohydrological background

Groundwater interactions play an important role in determining the function and distribution of many of the wetlands on and in the vicinity of Eskom’s Thyspunt site. SRK (2009) describe two major aquifers that underlie the site. These comprise:

- A primary, semi-unconfined aquifer, referred to both as the Algoa aquifer (after the superficial sand and cobble deposits of the Algoa Group that make up the aquifer) and as the intergranular aquifer, because groundwater flow and storage takes place within the original pore spaces between constituent grains (SRK 2009). The upper boundary of this aquifer is the water table – where the water table lies at or near ground level, wetlands have been formed; and
- A confined aquifer, within the fractured Table Mountain Group (TMG) bedrock that underlies the intergranular aquifer. Springs are common in the TMG and are fault or lithologically controlled by impeding layers such as the Cedarberg Formation (SRK 2009).

SRK (2009) describe groundwater flows across the site as predominantly from north-west to south east, with discharge along the beaches and rocky outcrops into the ocean, and into the Sand River[5] aquifer in the east. Groundwater flow generally follows the topographic gradient (SRK 2009).

Precipitation and runoff from the area to the north of the site, including the "panhandle" area (Figure 2.6) also seeps through the surface layers of highly porous, fine sandy and calcareous material to the base of the intergranular aquifer, where rapid flow occurs in the basal conglomerate and along the contact with the underlying TMG rocks. The groundwater flows out as seeps or springs within lower-lying areas of the dune fields and at sea-level. Because of the high hydraulic conductivity of the dunes, build-up of groundwater levels seldom occurs (SRK 2009).

All the groundwater samples have a dominant sodium/chloride-sulphate character with the samples from springs in the Algoa Aquifer showing a trend towards higher HCO_3 and Ca character than groundwater derived from boreholes in the TMG Aquifer (SRK 2009).

2.3.5 Classification of wetlands associated with the site

The following wetland types, classified at Level 4A and described at Levels 5 and 6 of the NWCS (SANBI 2009), occur within or in the vicinity of the Thyspunt site:

Wetland depressions within the mobile dunefields – these wetlands are also referred to as **duneslack wetlands**, and in terms of the NWCS, their Level 2 (Landscape Unit) classification would be that of "SLOPE". That is, they are depressions that occur in an otherwise sloped terrain. The wetlands form against the leeward toe of the mobile dunes and collectively comprise an extensive band of seasonally (or at least non-permanently) inundated pools, ranging from less than 30 cm in depth to over 2 m. The wetlands are aligned in a west-east direction, becoming more extensive in the east, where they widen to form swathes of permanently saturated, vegetated wetlands, which in places span a relatively high proportion of the dune width, and are linked at times by minor channels, which braid across the interdune surfaces. The approximate distribution of these wetlands is shown in Figure 2.6. This figure should however be used as a guideline to wetland extent only – the wetlands in fact are dynamic systems, undergoing shrinkage or expansion on an annual basis, and are periodically

5 The Sand river aquifer is the name ascribed to the portion of the intergranular aquifer, where it runs through the high dune ridge to the north of the site. In this report, however, the intergranular aquifer is simply referred to as the Algoa aquifer.

infilled by encroaching dunes. Illenberger (2009) describes two types of these wetlands from a geomorphological perspective, namely:

- "Static" systems, which are periodically filled with sand, as the mobile west-east moving dunes pass through them and
- [spatially] "Temporary" wetlands, that migrate with the eastward moving dunes.

From a wetlands habitat perspective, essentially ignoring the sometimes relatively short time scales over which these depressional wetlands form and re-form, two different wetland types are described in this report, namely:

- Vegetated, semi-permanent depressional wetlands, which occur mainly along the wetter northern edge and central to eastern extent of the Oyster Bay dunefield; and
- Unvegetated depressional wetlands, which probably equate largely to Illenberger (2009)'s [spatially] temporary wetlands, but which are also considered seasonal / non-permanent in terms of hydroperiod.

Permanently to seasonally saturated hillslope seeps – three distinct types of hillslope seeps occur on and in the vicinity of the site, distinguished on the basis of their geographical location, which has implications for wetland character in terms of specific geohydrological and geological influences, described in subsequent sections. The hillslope seeps identified comprise:

- Hillslope seeps, which occur where groundwater daylights along the coast (referred to in this report as "Coastal seeps");
- Hillslope seeps within the largely agricultural area to the north of the Oyster Bay dunefield – these feed into both artificially and naturally channelled valley bottom wetlands, which drain to the west of the site, as well as into the northern portion of the Oyster Bay dunefields; and
- Hillslope seeps arising in the area between the two mobile dunefields – the largest of these is the Langefonteinvlei, which comprises a northern and a southern section (Figure 2.6). Numerous smaller seeps occur at slightly higher elevations between the Langefonteinvlei and the Oyster Bay dunefield. It is noted that these seeps were classified in Day (2008) and WCS (2009) as valley bottom wetlands – in terms of the new definitions provided by the revised NWCS. However, FCG considers these systems to function primarily as hillslope seeps (SANBI 2009), many of which are characterised by depressions in the overall slope of the terrain, and which support standing water at times.

  Although the direction of groundwater movement south of the Oyster Bay dunefield is in an easterly or south easterly direction (SRK 2009), surface flows and shallow subsurface flows across the Langefonteinvlei drain towards the west, with the permanent trickle flow that appears to characterise these wetlands disappearing into the dunes to the south and west.

Permanently to seasonally saturated valley bottom wetlands: again, two distinct types of this wetland have been distinguished on and associated with the site, namely:

- Artificially and naturally channelled valley bottom wetlands, which occur in conjunction with extensive hillslope seeps within the largely agricultural area to the north of the Oyster Bay dunefield and either dissipate into the main dunefields (e.g. the Pennysands wetland) or drain to the east and the west of the site, feeding into the Sand and Slang Rivers respectively. In the vicinity of the Oyster Bay dunefield, these wetlands feed into a complex mosaic of depressional wetlands and wetland flats, which proliferate along the northern edge of the mobile dunes, particularly in the area just west and east of the “panhandle”; and

- Unchannelled valley bottom wetlands in the area between the two main mobile dune fields – these are fed largely by hillslope seeps day-lighting in this area, although they probably receive direct inflows from groundwater. The main unchannelled valley bottom wetland in this area is referred to in this report as the Eastern Valley Bottom wetland, described in some detail in Section 2.3.3.

2.3.6 Wetland surface and groundwater links

Information provided in this section has been extracted from Visser *et al*. (2011), and reflects current (2011) understanding of surface/ groundwater interactions in wetlands on and in the vicinity of the Thyspunt site. Previous versions of this report included debate of various hypotheses for wetland function presented by various authors (e.g. WCS 2009). Given the high levels of confidence attached to the findings of Visser *et al.* (2009), these hypotheses have been superseded by the information summarised below. Supporting data for the findings of Visser *et al*. (2011) can be sourced from that document, still in draft form at the time of preparing this report.

The duneslack wetlands of the Oyster Bay dunefield

The duneslack wetlands are formed primarily by daylighting of groundwater from the Algoa Aquifer in lowlying depressions within the dunefield (Visser *et al* 2011 and Appendix G). The more ephemeral duneslack depressions occur in the higher portions of the dunefield, towards the west. The more extensive wetlands are associated with the lower lying areas to the east, where the water table approaches the surface across a wider area. It is noted in this regard that the spread of water across a broader area of the dunefield in the eastern section may also reflect a reduction in wind-blown dune movement, beyond the crest of the high dune, allowing a deeper north-south penetration of flow pathways across the dune, from hillslope seeps to the north of the dunefield. Further west along the dunefield (e.g. in the vicinity of the panhandle), high rates of active sand transported down the west-east axis of the dunefield are thought to limit the extent of such north-south penetration, resulting in ponding of flows against the dunes.

- Localised perching may occur in places, above patchy layers of calcrete or aeolianite. The source of water contributing to these perched wetlands could be derived from through-flows (including seepage from the hillslope and valley bottom wetlands to the north of the Oyster Bay dunefield) and direct precipitation onto the dunes. During periods when the water table in the Algoa aquifer is elevated, it is also possible that the perched wetlands may also reflect daylighting of the raised water table, with impervious substrata simply retarding the rate of fall of the water table in these localised areas, resulting in an extended inundation period. In this regard, the likely interplay of local aquitards and larger scale aquifer processes in determining the existence of the duneslack wetlands must be recognised.

- Other forms of aquitard could arguably be found in wetlands where organic material accumulates over time. Although most of the wetlands appeared, during their dry periods, to be windblown to the extent that all wet-season plant material was removed, it is likely that some of the wetlands do accumulate organic detritus / algal material over time, resulting in the accumulation of a bed of organic material, with lower transmissivity / slower infiltration rates. Evidence for such events was seen in the dunefields, where erosion of active dunes revealed darkened layers in the sediment profile, indicative of the past accumulations of organic material in long-covered wetlands

- In addition to groundwater sources, the northern edge of the dunefields, including the portion abutting the so-called "panhandle", is fed by runoff from the Pennysands River, and (to the west) by runoff from unnamed valley bottom wetlands, fed by hillslope seeps (Figure 2.6). Water pools against the edge of the mobile dunes, and infiltrates its low-lying northern edge. [6]The near-perennial trickle that is assumed to be a feature of at least the Pennysands River, is assumed to contribute to the maintenance of the broad areas of wetland flats and depressions in this interface between the dunes and the vegetated valley bottom habitat. Again, increased plant growth in this area, and the ongoing accumulation of organic material associated with this growth, coupled with more stable conditions than in the mobile dune itself, may result in a cycle of increasingly reduced infiltration rates in the well-vegetated wetlands, and the spread of surface flows into the unvegetated and more mobile dune areas downstream.

The Langefonteinvlei

- The wetland soils in the Langefonteinvlei are characterised by a high organic content, resulting from the gradual build up of plant detritus on the wetland base. Hand auguring of sites within the wetland undertaken by FCG indicated that this layer extends in excess of 4m in depth, while analysis of the organic carbon content of these soils allowed their categorisation in places as Histosols (Soil Survey 2000), a group of organic soils which includes peats. This organic layer probably plays a role in reducing infiltration into the sandy underlying aquifer, leading to a self-perpetuating cycle of increased water retention in the wetland, which encourages the establishment and maintenance of the dense permanent wetland vegetation that characterises this hillslope seep.
    - The Langefonteinvlei is fed by groundwater flowing from the mobile Oyster Bay dune field in the north and the water divide in the northeast. This water emerges in the form of surface springs and seeps at the foot of the high dune in the north and north-eastern portions of the Langefonteinvlei. From here, the exposed groundwater flows as surface flow on and in the humus-rich layer of the wetland, down-slope towards the south and southwest of the wetland (Visser et al. 2011).
    - A watershed at the head of the Langefonteinvlei separates westerly seeping surface water (the Langefonteinvlei) from easterly seeping water (the Eastern Valley Bottom wetland.
    - Groundwater from the higher-lying northern portion of the Langefonteinvlei passes in a south / south easterly direction through the low dune ridge separating the southern, smaller portion of the wetland from the northern portion
    - Beneath the southern and south-western portions of the Langefonteinvlei, the groundwater table lies beneath the wetland and is not directly linked to

[6] Assumption based on the trickle flows still in evidence along most of the channel in September 2009, even when many of the wetlands across the site were no longer inundated

it. In other words, the water in these portions of the wetland is perched above the groundwater table of the Algoa Aquifer.

- It is postulated (Visser *et al*. 2011) that the western extent of the Langefonteinvlei is determined by a balance between inflow and evapotranspiration. In other words, the water flows on the surface and in the humus layer until it is used up by evapotranspiration.
- The humus layer is porous but relatively impermeable and water stored in this layer buffers the wetlands through drought periods.

The above conceptual model of surface / groundwater interactions in the Langefonteinvlei is presented graphically in Figure 2.8, after Visser *et al.* (2011), with Figure 2.7 illustrating the locations of cross-sections through the Langefonteinvlei, as depicted in Figure 2.8.

The coastal seep wetlands

Coastal seep wetlands, located southwest and west of the Langefonteinvlei, including the major spring at White Point (asterisked in Figure 2.6), are not fed by the Langefonteinvlei. These wetlands emerge near the coast where the bedrock is close to the surface and are fed by groundwater draining from the Algoa Aquifer and TMG Aquifer to the ocean. Groundwater does not pass from the Langefonteinvlei westwards into any of these wetlands (Visser et al. 2011).

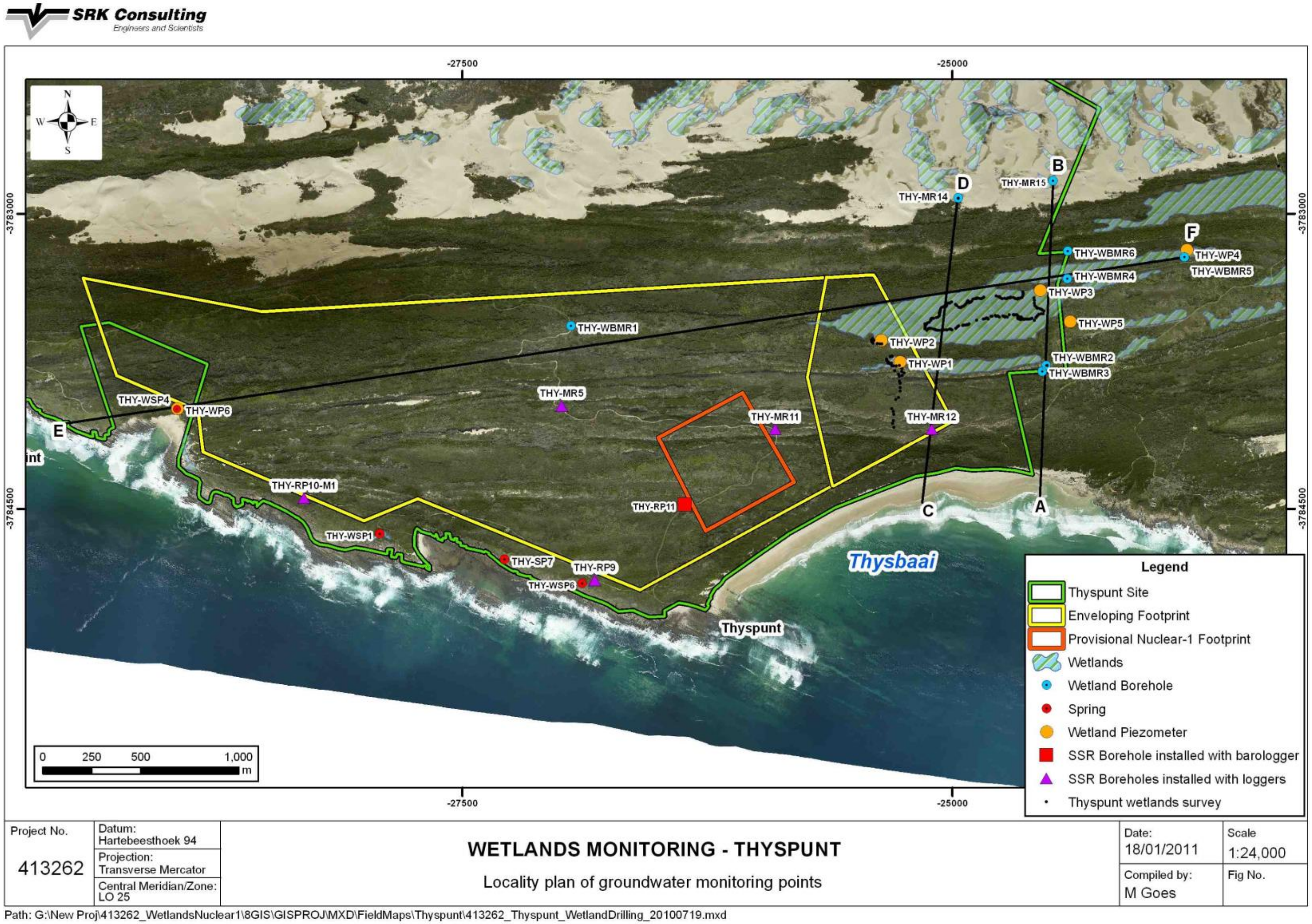
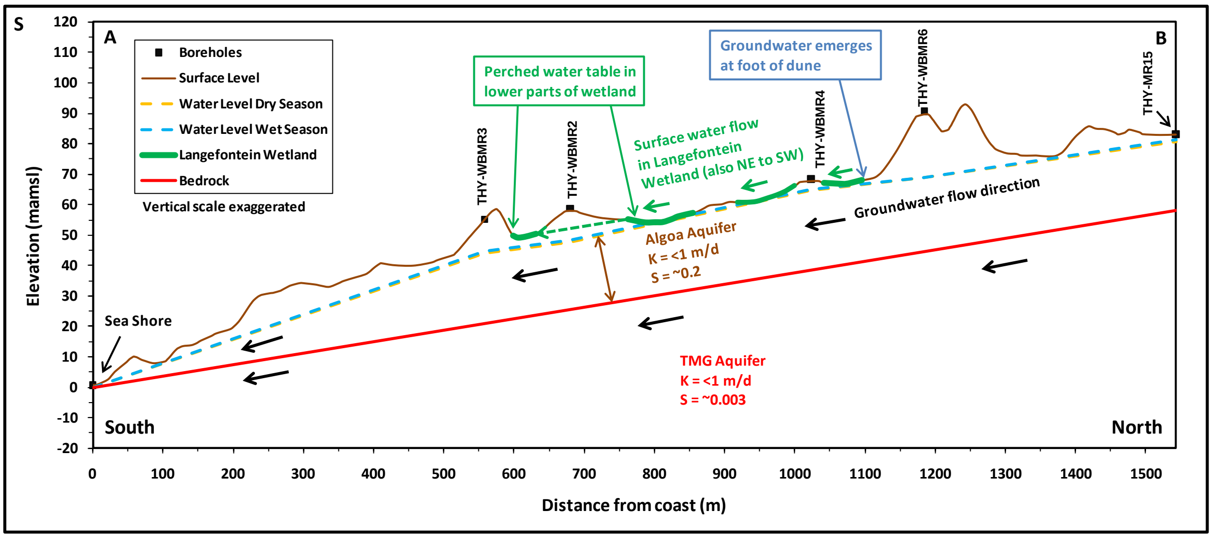


Figure 2.7 **Positions of cross-sectional views, shown in Figure 2.8, to depict the conceptual model of surface – groundwater interactions in the Langefonteinvlei. Figure after Visser et al. (2011).**



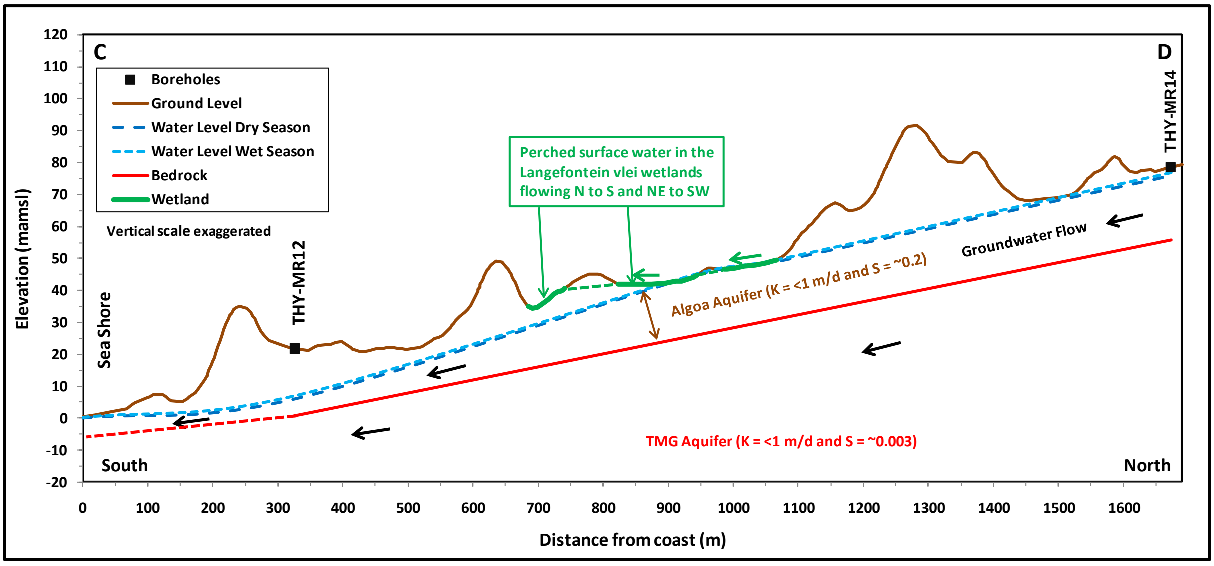


Figure 2.8 **Cross-sectional views depicting the conceptual model of surface – groundwater interactions in the Langefonteinvlei. Cross-sections from areas shown in Figure 2.7. Figure after Visser *et al.* (2011).**

2.3.7 Description of wetland physical, chemical and biological attributes

This section provides summary information regarding the major hydrological drivers, physical, chemical and biological characteristics of the wetlands identified on and in the vicinity of the Thyspunt site. A number of sites were sampled for water quality and invertebrate biota, (refer to Figure 2.6 for site locations).

Table 2.7 presents the water chemistry at these sites and Figure 2.9 summarises anion / cation molar concentrations at selected sites. In addition to the water quality data presented in Table 2.7, EC data were measured at some 22 of the coastal seeps between the western site boundary and the sandy beach at the Thyspunt point. These data are described in the relevant text in the wetland descriptions that follow. Table 2.8 and Figure 2.10 provide aquatic invertebrate data from samples collected from the sites. Information regarding the regional context of aquatic invertebrate data is provided in Appendix E, and referred to where relevant in the text.

The chemical and biological data were all used in descriptions of the wetland sites that are included in Table 2.8, each representing a particular wetland type.

Additional data collected since the completion of the EIA study have been analysed and discussed in Visser *et al* (2011). These data are alluded to in places, where they add value to discussions of wetland function. However, they have not been included in this report in full.

Table 2.6 Water quality in sampled wetland sites at Thyspunt

Site locations as shown in Figure 2.6 and/or described in Table 2.8. N-DS: duneslack on the northern dune edge near Pennysands;

* data collected by SRK in June 2008.

[#] data collected by FCG in Sept 2009

** data collected by FCG in July 2007

	Ca mg/L	K mg/L	Mg mg/L	Na mg/L	SO4 mg/L	Cl mg/L	EC mS/m	pH	NO_3-N µg/L	Ortho-P µg/L	Fe mg/L	Mn mg/L	NH_4-N µg/L	F mg/L	$CaCO_3$ mg/L
Slang River	78.4	2.7	12.1	85.3	17.5	143		7.1	411	42					
[#]N_DS	81.2	18.3	11.5	38.9	4	53.3	74.5	7.4							
[#]DS_a	111	1.9	9.5	47	7.7	10		8.1	26	33					
[#]Ds_b	31.6	1.8	20.1	47.6	3.9	84.1	67.5	8.4							
[#]Ds_c	23	1.1	9.5	28.3	32.3	57.7	64.8	8.5							
****DS1B**							60.5	8.125	44	<25					
****DS1C**							63	8.25	<25	<25					
****DS2A**							116	8.03	<25	51					
[#]Sand River	61.2	2.2	15.2	96.3	54.9	203	113.1	8.5							
****HS_Lang**	74.4	1.6	7	30.6	32.3	57.7	74.7	6.78							
***HS_Lang1**	107.2	1.5	11.1	49.9	6.1	82	78	8.3	<25	<25	<0.05	<0.05	66	0.16	294
****Lang_Pond**	137.1	2.7	20.9	138.3	89.2	224	138	7.5	<25	<25	<0.05	<0.05	97	0.22	321
****VB_east**	146.2	1	14.1	120.2	20.4	64	65.9	6.91	<10	45					
***CS1**	119.2	3.9	20.1	214.9	57.9	330	161	8.0	73	33	<0.05	<0.05	41	0.14	255
***CS2**	95	2.4	14.9	121.9	40	203	114	8.4	767	54	<0.05	<0.05	53	0.15	230
***CS3**	93.1	2.3	14.3	114.3	39.6	206	109	8.2	917	67	<0.05	<0.05	40	0.16	208
***CS4**	84.1	2.2	12.7	90.5	31.8	163	92	8.3	908	60	<0.05	<0.05	68	0.15	203

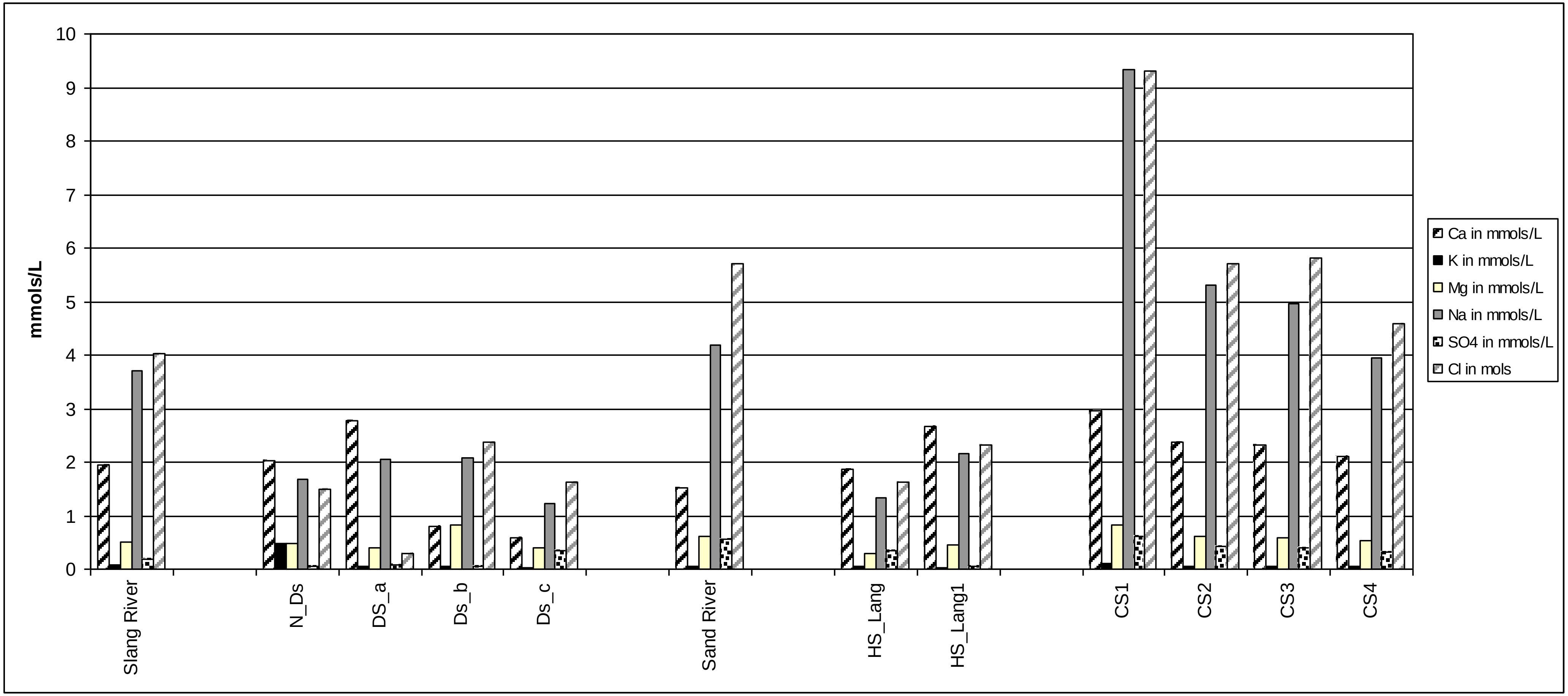


Figure 2.9 Comparison of major anions and cations at selected sample sites on and in the vicinity of the Thyspunt site. Data provided in Table 2.7.

Table 2.7 List of taxa from seven wetland samples collected at Thyspunt

Taxa organised by major groups, taxonomic order, family and then species. Taxa with "?" denotes an uncertainty of species designation, "c.f." means that taxon keyed out to this point in the taxonomic reference used (typically a key from another region of the world) and is the closest designation, may or may not be within this genus. Abundance ratings on log scale as follows: A = 1, B = 2-10, C = 11-20, D = 21-100, E >100. Note that the sample representative of the Langefonteinvlei wetland was in fact collected from site VB2, east of the Thyspunt site boundary, due to limited standing water in the Langefonteinvlei at the time of sampling. Site locations shown in Figure 2.6.

Order	Family	Taxon	Common Name	DS1B	DS1C	DS2A	DS3A	Lang/ VB2	CS1
Anura	Ranidae	*Phrynobatrachus natalensis*	Natal puddle frog				A		
	Pipidae	*Xenopus* sp.	Platanna frog	A					
Seriata:Tricladia	Planariidae	*Dugesia* sp.	flatworms			A			
Amphipoda: Corophiidea	Corophiidae	*?Neomicrodeutopus nyala*	sand fleas						C
Amphipoda: Gammaridea	Talitridae: Hyalellinae	*Hyale ?grandicornis*							D
Isopoda:Flabellifera	Sphaeromatidae	*"Pseudosphaeroma" barnardi*	pill bugs						A
	Anthuridae	*Cyathura estuaria?*							A
Tanaidacea: Dikonophora	Tanaidae	*Sinelobus stanfordi*	-						B
Cladocera	Daphnidae	*Simocephalus vetulus*	water fleas				B		
	Chydoridae	*Pseudochydorus gr. globosus*					A		
	Moinidae	*Moina tenuicornis*					A		
Copepodae:Calanoida	Diaptomidae	*Metadiaptomus meridianus*	-	B					
Copepodae:Cyclopoida	Cyclopidae	*Paracyclops* sp.		A					
		Thermocyclops oblongatus?					B	B	
Ostracoda	Darwinulidae	*?Darwinula stevensoni*	seed shrimps					B	
	Cyprididae	Cyprididae sp.			A				
Pulmonata	Lymnaeidae	*Limnaea columella*				B			
Oribatida	Oribatidae	Oribatidae spp.	soil mites		B	B			
Collembola	Poduridea	c.f. *Podura* sp.	spring tails		A				
Coleoptera	Dytiscidae	*Hydrovatus* sp. larvae	tiger beetles			B	B		

Order	Family	Taxon	Common Name	DS1B	DS1C	DS2A	DS3A	Lang/ VB2	CS1
		Uvarus sp. adult					A		
		c.f. *Bidessonotus* sp. adult					B		
		Cybister sp. adults				A			
		Derovatellus sp. adults		C		B			
		c.f. *Hydroporus* sp. larvae		D	B				
		Hydaticus (Guignotites) sp. larvae				A		A	
	Noteridae	*Hydrocanthus* sp. adults	burrowing water beetles					B	
	Gyrinidae: Gyrininae	*Gyrinus vicinus* larvae	whirligig beetles				A		
	Hydraenidae: Ochthebiinae	*Ochthebius* sp. adults	minute moss beetles	B					
	Hydrophilidae: Hydrophilinae	*Berosus* sp. adult	water scavenger beetles				B	A	
Diptera	Ceratopogonidae: Ceratopogoninae	*Bezzia* sp. larvae	biting midges, no-see-ums		B				
	Ceratopogonidae: Dasyheleinae	*Dasyhelea* sp. larvae		A					
		Dasyhelea sp. pupae					A		
	Ceratopogonidae: Forcipomyiinae	*Atrichopogon* sp. larvae					A		
	Chironomidae	Chironomidae spp. Adults	non-biting midges	B	B			A	
	Chironomidae: Chironominae	*Cladotanytasus* sp. larvae					B		
		Polypedilum spp. larvae		D	B	C		D	
		Tanytarsus spp. larvae		B	C		C	B	
		Tanytarsus sp. pupae		A	B				
	Chironomidae: Orthocladiinae	*Cricotopus* spp. larvae		E	D	D	D	C	
		Corynoneura spp. larvae			C	D		B	
		Orthocladiinae sp. larvae			B				
		Orthocladius sp. larvae		B	B		D		
		Parametriocnemus sp. larvae		B	B		B		
		Parametriocnemus sp. pupae			B				
		Rheocricotopus spp. larvae			C	D	D	C	B
		Thienemanniella sp. larvae							C

Order	Family	Taxon	Common Name	DS1B	DS1C	DS2A	DS3A	Lang/ VB2	CS1
		Thienemanniella sp. pupae							A
		Tvetenia calvescens larvae		D	D	D			B
	Chironomidae: Tanypodinae	*Ablabesmyia* sp. larvae			C				B
		Clinotanypus sp. larvae							
		Larsia spp. larvae			D		C		
		Nilotanypus sp. larvae					A		
		Paramerina spp. larvae		B	D	C	D	B	
		Paramerina spp. pupae		C	B	B	B		
		Procladius sp. pupae		B					
		Tanypodinae sp. pupae		A					
		Thienemannimyia sp. larvae					B	A	
		Thienemannimyia sp. pupae					B		
	Dixidae	*Dixa* sp. larvae	meniscus midges					A	
	Sciomyzidae	Sciomyzidae sp. larvae	marsh flies				A		
	Stratiomyidae	Stratiomyidae sp. larvae	soldier flies		A				
	unspecified	Diptera sp. adult	flies	B					
Ephemeroptera	Baetidae	*Cloeon* spp.	minnow mayflies	E	D	D	D	E	
	Caenidae	*Caenis* sp.	cainflies	C	A	C	D	B	
Hemiptera	Corixidae	*Sigara* spp. nymphs	water boatmen				B	B	
		Sigara spp. adults		B			B		
	Gerridae: Gerrinae	*Limnogonus* c.f. *capensis*	water striders, pond skaters						
		Aquarius distanti			B				
	Gerridae: Rhagadotarsinae	*Rhagodotarsus hutchinsonii*			B				
	Notonectidae	*Anisops* spp. adults	backswimmers	C	C	A	B	B	
		Enithares sp. adults						A	
	Pleidae	*Plea* spp. adults	pigmy backswimmers			B		B	

Order	Family	Taxon	Common Name	DS1B	DS1C	DS2A	DS3A	Lang/ VB2	CS1
	Veliidae	Veliidae sp. nymph	water crickets					A	
	Aphididae	*Aphis* sp. terrestrial	aphid, terrestrial		B				
Odonata: Anisoptera	Aeshnidae	*Aeshna subpupillata?*	stream hawker dragonflies					B	
		Anax ephippiger/speratus	emperor dragonflies		B	B			
	Gomphidae	*Notogomphus praetorius*	yellowjack dragonflies		B				
	Libellulidae	*Diplacodes lefebvrii*	black percher dragonflies				C		
		Diplacodes sp.	percher dragonflies	B	C	B			
		Orthetrum sp.	darter dragonflies			A			
Odonata: Zygoptera	Coenagrionidae	*Ischnura senegalensis*	blue damselflies	A	D	D	B	B	
	Lestidae	*Lestes plagiatus/virgatus*	emerald damselflies				C	B	
Trichoptera	Hydroptilidae	*Oxyethira velocipes*	purse-cased caddisflies	A	D	D	C	B	
			Total number of taxa	**27**	**24**	**31**	**35**	**25**	**10**

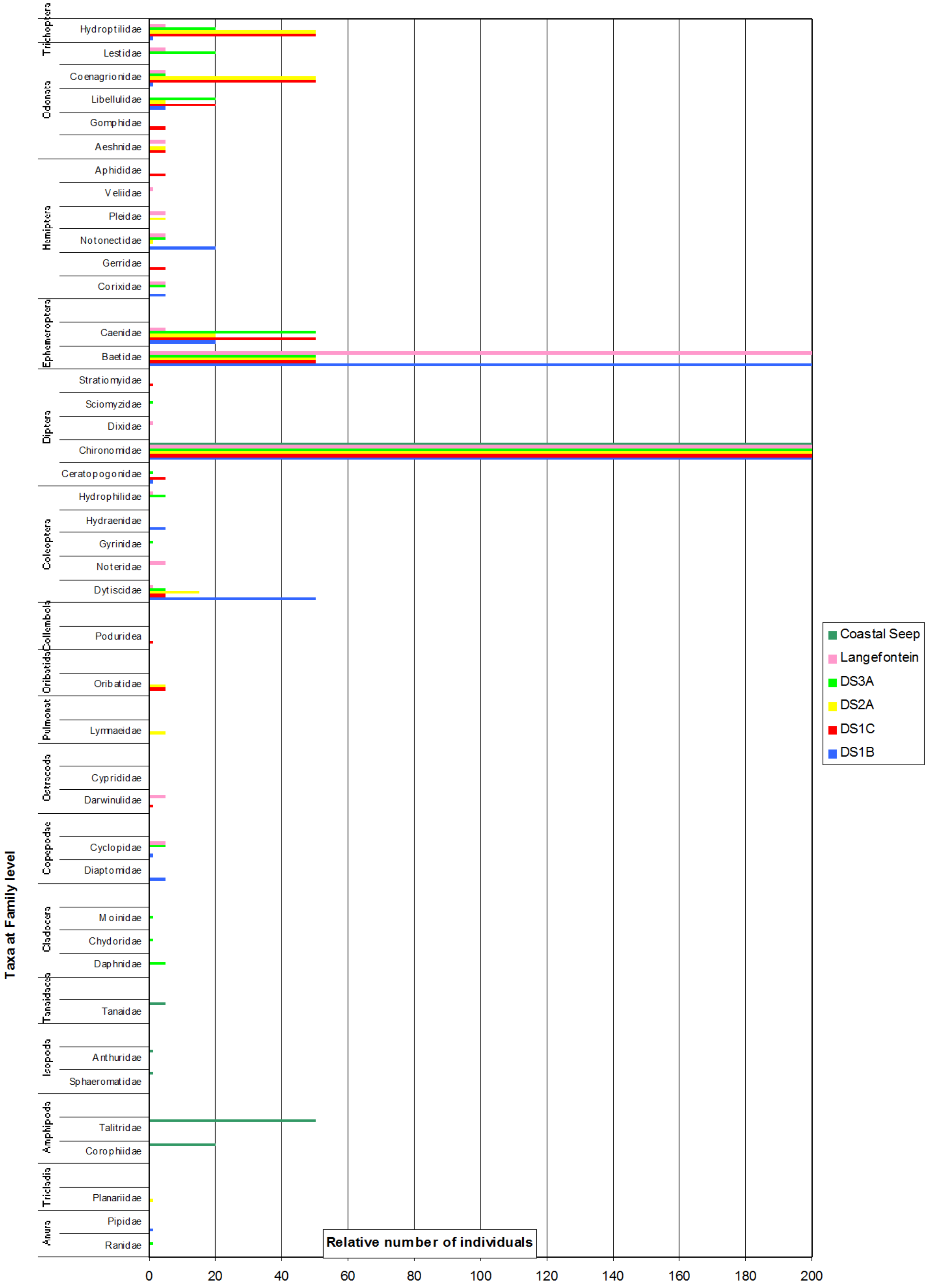


Figure 2.10 **Summary data showing relative abundance of aquatic invertebrate fauna in different habitats at the Thyspunt site.** Note that relative and not absolute abundance has been shown – Y-axis reflects the median of abundance groups A-E (as defined in Table 9). Invertebrates grouped to level of family.

Table 2.8 Summary information regarding major wetland types identified in Section 2.3.5

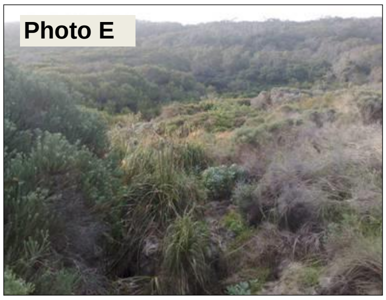
1 DEPRESSIONS	
Wetland type	**Wetland depressions (duneslack wetlands)** within the mobile dunefields • Vegetated, permanently saturated and periodically inundated depressional wetlands • Unvegetated, periodically inundated and spatially temporal depressional wetlands
Examples Photo A: Typical example of relatively transient duneslack wetland in the central portion of the Oyster Bay dunefield Photo B: Permanently inundated to saturated, wetland depressions along the northern margin of the Oyster Bay dunefield – these wetlands receive constant trickle surface and shallow subsurface flows from the hillslope seeps and valley bottom wetlands to the north of the dunefield, including from the so-called "panhandle" portion of the Eskom site	 
Data prefix	DS (DSa, DSb and DS1 etc)
Extent on site	Figure 2.6 provides an indication of the extent of these wetlands on the Oyster Bay dunefield. The duneslack depressions are extensive on the central and eastern portion of the Oyster Bay dunefield. In general, they are discrete systems, which form in low lying depressions in the dunes. However, they increase in both extent and permanence towards the east, while the wetlands in the west are more transient (that is, they disappear and re-form with west-east dune movement (Illenberger 2009). The well-vegetated depressions shown in Photo B occur along the northern edge of the dunefield, and are apparently associated with permanent inflows of water from hillslope seeps and (on the Thyspunt site in the vicinity of the "panhandle") the so-called Pennysands River or valley bottom wetland. Water from the latter system pools against the dunes, and infiltrates slowly, forming

	extensive (sometimes black water) wetlands along the dune edge. Wind is the major driver of dune mobility in the western section of the dunes (Prof. Ellery, Rhodes University, pers. comm.) and this west-east movement is assumed to limit north-south penetration by rivers, which instead pool and percolate into the sands more slowly.
Botanical characteristics Note Low (2009) provides full descriptions and analyses of wetland flora at this site and only dominant species or those of particular interest are listed here	The duneslack wetlands of the Oyster Bay dunefield all fall within the Southern Cape Dune Fynbos vegetation type (Low 2009). Low (2009) recorded 43 plant species in the transverse dune wetlands, three of which are IUCN listed Red Data species. Submerged and floating aquatic vegetation in many of the inundated duneslack wetlands included dense growths of the aquatic weed *Chara* sp. as well as alga (*Cladophora* sp). Of these, the former is common in seasonal, alkaline wetlands (Cook 2004) and the latter occurs across a range of seasonal and perennial wetland systems. The ephemeral duneslack depressions, which run in a line through the main axis of the dunefield, tend to be sparsely vegetated, with the main plants occurring along their margins comprising *Ficinia nodosa* and stands of the regional endemic *Merxmuellera cincta* subsp. sericea (IUCN listed as Vulnerable) (Low 2009). The vegetated depressions, which occur mainly along the northern margins and eastern sector of the dunefield include stands of *Cyperus mariscus* in wetter areas; *Phragmites australis* and /or *Typha capensis* in permanently saturated and often nutrient enriched areas; *Juncus kraussii* and *Juncus capensis* in seasonally inundated areas and, in probably perennially saturated areas to shallowly inundated areas, dense growths of species including *Centella asiatica* and *Berula erecta*. Wetland margins and drier wetland flats along the northern edge include patches of *Helichrysum cymosum*, *Senecio* spp. *Merxmuellera cincta* subsp. *sericea*
Physico chemical characteristics	Standing water in the duneslack wetlands was mildly alkaline at all sites assessed – an expected result in these coastal systems, and associated with relatively high levels of calcium carbonate. EC values varied between systems, but all values were indicative of fresh water with low salt content (38 – 116 mS/m). EC values were slightly lower than the groundwater EC values presented by SRK (2009). That study identified EC zones based on ranges of conductivity. Most of the site falls within their zone of EC between 70 – 300 mS/m. This broad categorisation of EC does not include seasonal values and the slightly lower EC values recorded in this study could well be accounted for by seasonal variation, given that sampling occurred during the wet seasonal when precipitation on surface systems will reduce EC. Nutrient concentrations at all of the duneslack wetland sites indicated oligotrophic conditions with respect to nitrogen nutrients (Table 2.3). Phosphorus concentrations in relatively non-vegetated, transient wetlands along the main spine of the dunefield were < 0.025 mg/l, and probably also indicative of oligotrophic systems, based on the low levels of algae in these systems (DWAF 1996). Vegetated wetlands that were sampled along the northern edge of the dunefields were visibly more productive than the smaller systems

	assessed in terms of algae and other plants and would be classified as mestrophic to mildly eutrophic in terms of DWAF (2002)'s broad ecosystem guidelines. Virtually all of this nutrient was in the biologically available form of soluble reactive phosphorus or orthophosphate, and assumed to result mainly from cattle dung in these grazed wetland areas. This interpretation is supported by the elevated concentrations of total ammonia at sampled sites (Table 2.7). Relatively high total ammonia concentrations appear to be characteristic of many mildly nutrient enriched depressional wetlands, presumably a reflection of poor aeration in shallow standing waters. Overall, water chemistry in the dune slack wetlands ranged between oligotrophic and mildly eutrophic conditions, with slight nutrient enrichment associated with the northern wetlands, where grazing by cattle occurs and where one of the sources of water is seepage water from the northern agricultural areas. The duneslack wetlands are all sodium-chloride dominated (Figure 2.7), but like the groundwater in the Algoa aquifer, also have a relatively high calcium component, consistent with their location in largely calcareous sands / limestone rich areas.
Aquatic invertebrates	The duneslack wetlands at Thyspunt showed the highest diversity of all wetlands associated with this site (Table 2.7 and Figure 2.10). Nevertheless, they are distinguished in multivariate analyses from other duneslack wetlands in the Western and (southern) Cape (Appendix E) on the basis of their dominance by insect taxa, and their low diversity of microcrustaceans. This is probably attributable to the transient nature of at least the unvegetated wetlands along the main dunefield. Such transience presumably does not provide a stable habitat for taxa that have evolved to survive dry periods through diapause or through desiccation resistant eggs (Day *et al*. 2009) but which are not especially effective at surviving the consequences of advancing dunes or re-colonising newly formed wetlands in their wake. Crustacean fauna that were found in the wetland habitats included mainly copepod (both grazer and invertebrate predators) and benthic ostracod taxa, all of which are considered cosmopolitan species (Rayner 2001). Not surprisingly, the greatest number of taxa (35) occurred in the more structurally diverse, vegetated wetlands along the northern margins of the dunes (e.g. DS3A Table 9). All sites were dominated in terms of number by dipterans – mainly grazing chironomid larvae (sub-families Orthocladiinae and Chironominae), as well as members of the predacious subfamily Tanypodinae. Ephemeropterans (*Cloeon* spp. and Caenis sp.) were also common in these wetlands, as were trichopterans (*Oxyethira velocipes*). Odonate taxa were diverse, with at least six different species identified across the duneslack wetlands, although samples were dominated by coenagrionid damselflies (*Ischnura senagelensis*). These species are however all considered fairly wide spread (Schael 2008). The gastropod *Limnaea columella,* which was found at low numbers in the more permanent vegetated wetlands, is an alien invasive from North America.

Other wetland fauna	Harrison *et al.* (2009) noted the presence of a number of larger faunal species that are wholly or partially reliant on the duneslack wetlands during at least part their life cycles. These include the Cape Sand Toad *Vandijkophrynus angusticeps,* a species described by Harrisson *et al*. (2009) as of special interest because it is at the eastern extremity of its range at Thyspunt. This species is probably isolated from all others populations of this species and may, therefore, be genetically and even taxonomically distinct. Footprints observed in and around the wetlands during site visits indicate that they are also watering areas for terrestrial fauna, including Caracal, Leopard, various small antelope, mongooses and otters.
Source(s) of water	Main sources of water are believed to comprise: • Groundwater from the Algoa aquifer; • Contribution by local rainfall onto dune areas; and • Contribution in some areas by stream flow (hillslope seeps and valley bottom wetlands) from the areas to the north of the dunefield – particularly in the Pennysands River area
Occurrence of wetland type in the broader region	Duneslack wetlands and particularly those associated with the mobile dune system are not known to occur elsewhere in South Africa <u>on the scale</u> at which they occur in the Oyster Bay system. Isolated wetland depressions do occur in the nearby Thysbaai dunefield, east of the Thyspunt boundaries. These are however far less abundant, more intensely invaded by alien vegetation, and presumably part of a smaller (but geohydrologically linked) system than the main Oyster Bay / Sand River system to the north.
Links with other ecosystems	The duneslack wetlands as a group are considered a singularly important component of the overall habitat diversity of the site. To the north, they link with the permanently saturated to inundated depressions and valley bottoms along the edge of the farmland. Much of the natural connectivity between these different habitats has however been fragmented by agricultural activities. The ecological links between the duneslack wetlands and terrestrial habitat to the south of the high dune fields is thus considered of significantly greater importance, given the fact that these systems have been largely protected, at least within the Eskom area itself, from impacts such as agriculture and burgeoning resort development that threaten the system on either side.
Special attributes	The duneslack wetlands along with the Oyster Bay dunefield is considered by many wetland ecologists (including the present author) to be a highly complex, one-of-a-kind system, the exact functioning of which has not yet been adequately explained.
Key uncertainties	Surface groundwater linkages, and the exact role of local aquitards versus the regional groundwater level, as set by the primary (Algoa) aquifer in promoting wetland extent; the role of groundwater in determining large-scale dune morphology.
Key sensitivities	The wetlands are considered highly sensitive to activities that will disrupt their supply of water on a long-term basis – since uncertainty still remains regarding water supply dynamics, such activities could include: • Activities that affect the flow of water onto the dunes from the north, including activities that affect water flow through the

	Pennysands wetlands into the dunes on the Eskom site; • Activities resulting in lowering of the primary aquifer level in the dunefield area; and • Activities affecting the integrity of local areas of low permeability. The wetlands are probably not highly sensitive to short-term impacts in water supply – that is, over a few months, other than if these contribute to dune instability, thus affecting dune geomorphological processes.

2 PERMANENTLY TO SEASONALLY SATURATED HILLSLOPE SEEPS	
Wetland type	**A Coastal seeps** – "hillslope seeps day-lighting along the coast"
Examples **Photo C**: Freshwater pool just above high water mark **Photo D**: *Phragmites australis* seep down to tidal edge **Photo E**: broad hillslope seep leading to major coastal seep near White Point (* in Figure 2.6) **Photo F**: outlet of major coastal seep near White Point (* in Figure 2.6)	   
Data prefix	CS1; CS2 etc
Extent on site and general description	These wetlands comprise numerous small seeps, which arise just above the high water mark along the rocky shore. They are formed in areas where groundwater, moving along the base of the intergranular aquifer, daylights at the contact with the underlying TMG bedrock along the rocky shore (SRK 2009), forming an array of small springs and seeps (Photo C). Although the individual seeps themselves are small, they form a mosaic of wetland habitat just above the rocky shore to the east of the Thyspunt point, occurring as wide swathes (up to 40m wide) of wetland vegetation. The passage of fresh water into the sea also occurs along the beach, where at times small trickles of fresh water appear – the extent of physical disturbance associated with the beach dynamics and the variable volumes of flow mean that the surface water that does appear has not been sufficient for the establishment of wetland conditions in these zones.

	On the site, the coastal seep wetlands occur along the rocky shore west of the sandy beach and Thyspunt point itself, as far as the western site boundary and extending on towards Oyster Bay. The highest density of these seeps lies towards the east, in the vicinity of Thyspunt, where the seeps form wide expanses of vegetated freshwater wetland, just above the high shore mark (Figure 2.6). In the vicinity of Oyster Bay, many of the seeps have been drained and infilled to make way for houses and road infrastructure. GPS reference points were taken to demarcate the coastal seeps day-lighting within the Eskom site boundaries. Based on these, the wetland extents were desk-top mapped, as shown in Figure 2.6, and include pools of fresh, standing water, immediately above the marine spray line (Photo C), trickle flow along steeply sloping rocky channels and, where flat platforms exist above the wave platform, broad bands of saturated soil, supporting dense reedbed (Photo D). The largest of the seeps has been asterisked in Figure 2.6. This seep is the only one of the coastal seeps that extends beyond the 200m coastal setback line shown in Figure 2.6, and is a channelled system, passing through a dense swathe of saturated vegetation. It daylights at the base of a low dune ridge, and is assumed to flow permanently, with flow trickling down its channel even during periods when many wetlands on the site were dry (September 2009). Towards the west of the site, the wetlands are spaced further apart, and are fed by longer drainage lines off the tall dunes. Where settlements abut the drainage lines, some of the wetlands have been impounded to facilitate abstraction of fresh water for domestic use. Large scale recent efforts by Eskom to clear woody invasive alien vegetation from the dune slopes has probably increased flow rates along many of these seepage lines, potentially also resulting in a short-term increase in erosion potential in cleared areas, until re-establishment of indigenous vegetation has occurred.
Botanical characteristics Note Low (2009) provides full descriptions and analyses of wetland flora at this site and only dominant species or those of particular interest are listed here	The coastal seeps, described by Low (2009) as "the coastal wetland community", are dominated variously by dense stands of *Cyperus thunbergii, Juncus kraussii, Phragmites australis* and even the freshwater restricted (Hall 1990) *Typha capensis*, with *Helichrysum gymnoconum*, *Hypoestes aristata* and *Senecio helimifolius* occurring along the wetland margins. Low (2009) notes that these wetlands are characterised by surprisingly high species numbers for wetland habitat (52), one of which is a Red Data species. The high species diversity may be due to the location of these wetlands on the interface of three distinct zones – terrestrial/freshwater and marine.
Physico chemical characteristics	A full water chemistry analysis was conducted on samples from only one coastal seep. These data indicated, *inter alia*, that the assessed seep was both relatively fresh (EC 55 mS/m), and mesotrophic with respect to phosphorus enrichment. A survey of all of the coastal seeps between the western Eskom boundary and Thyspunt itself indicated, however, a range in salinity in these wetlands, corresponding to the range in salinity tolerances of wetland plants found in the different seepage areas. EC levels in the seeps closer to the ranged between a slightly brackish 394 mS/m seep just above the high tide mark, to several seeps with EC levels around 88 mS/m. These and the seep sampled for analysis of nutrients flowed off the steep slopes of a high dune, and may thus have been subject to fewer marine influences in terms of salinity than the lower lying seeps

	assessed in the coastal survey. Mean EC of the 22 measured seeps was 240 mS/m. The seeps were all more saline than the non-coastal wetlands on the site, but were also sodium-chloride dominated with a high calcium component, suggesting that they are fed by in the Algoa aquifer, a supposition confirmed by more detailed data analyses provided in Visser *et al.* (2011).
Aquatic invertebrates	Aquatic invertebrates sampled in trickling flow and standing water pools in the assessed coastal seep wetlands indicated communities that were completely different from those in other habitat types at the Thyspunt site, with the exception of the chironomids which were common to most samples. Diversity was low with only 10 different taxa identified, and the fauna was dominated by marine or estuarine groups, such as estuarine amphipods, isopods and a tanaid. The tanaid, *Sinelobus stanfordi* is a crustacean known from coastal lagoons, lakes and estuaries and has been recorded from Saldanha in the Western Cape and Nhlange, Kosi and Mpungwana in KwaZulu Natal to date (Kensley 2001). Multivariate analyses (Appendix E) indicated high dissimilarity between the coastal seep invertebrate fauna and those of other wetlands in the database, largely because of the low diversity and presence of marine amphipods, which clearly have a high tolerance of fresher conditions.
Other wetland fauna Detailed descriptions of fauna associated with the seeps is provided in Harrison et al. (2009)	The coastal seep wetlands provide a source of clean fresh water for small mammals such as otters and mongooses as well as small antelope and other fauna.) Harrison *et al*. (2009) noted the occurrence of Cape Clawless Otter *Aonyx capensis,* Marsh Mongoose *Atilax paludinosus,* as well as antelope, probably Bushbuck *Tragelaphus scriptus* and Common Duiker *Sylvicapra grimmia* in the vicinity of the coastal wetlands. Caracal spore were also observed during a site visit. Large freshwater pools are attractive habitats for otters, which are believed to move between the shallow sub tidal area, where they forage for molluscs, fish and crustaceans, and the terrestrial wetlands, which afford them fresh water for drinking, swimming and playing. The wetland seeps are presently largely undisturbed by human traffic, increasing their value as habitat to shy, larger mammals such as these, and thus increasing the diversity of fauna associated with the coastal zone on the site.
Source(s) of water	The coastal seeps derive virtually all of their water from groundwater flows from the Algoa aquifer, which daylight at the foot of the dune system, at the contact with the TMG wave cut platform (Visser *et al*. 2011). Rainwater is not expected to contribute substantially as a water source, as this is largely absorbed in the unsaturated zones of the dunes (SRK 2009).
Occurrence of wetland type in the broader region	Coastal seep wetlands *per se* are a common feature along many areas of the southern Cape, and are prevalent outside of the Eskom site, occurring within Oyster Bay and west along the coast, as well as east along the coast towards St. Francis Bay. What is significant (but not unique) about the coastal seep habitats at Thyspunt is their relatively unimpacted condition. By contrast, all of

	the seepage wetlands identified in the Oyster Bay region outside of the Thyspunt site were dominated by *Typha capensis* within developed areas, subject to extensive drainage (precipitating head cut erosion in some cases) and frequently infested by weedy plants and garden escapees. *Typha capensis* is invasive under disturbed wetland conditions and in dense stands is associated with reduced habitat quality for wetland fauna. Virtually all remnant stands of wetland outside of the actual drainage lines were earmarked for development as residential stands along this stretch of coastline, suggesting that this wetland type is locally under threat.
Links with other ecosystems	The coastal seep wetlands link laterally with each other, forming a stepping-stone mosaic of wetland habitats along the rocky coastline. They are linked geohydrologically with some of the duneslack, hillslope seep and valley bottom wetlands between the Oyster Bay dunefield and the coast and may also play a role as ecological corridors, facilitating the movement of mammals between the coast and the dune areas.
Special attributes	Although small when considered at the level of the individual wetland, together these wetland seeps contribute substantially to the diversity of habitat available along the coast, and provide a habitat type which, while not at the same level of unreplicated, one-of-a-kind habitat as the duneslack wetlands and hillslope seeps of Langefonteinvlei and surrounds, is nevertheless considered highly threatened and on a regional trajectory of degradation, in line with increasing coastal resort and other development.
Key sensitivities	The coastal seeps are likely to be sensitive to changes in water quantity, with concentration of flows potentially leading to headcut erosion and concentration of flows, and reduced inflows resulting in increased salinities close to the sea, and general wetland shrinkage. The seeps would be susceptible to increases in salinity, which could alter soil quality on a permanent basis, and see a shift to a marine rather than a freshwater ecosystem community.

2 PERMANENTLY TO SEASONALLY SATURATED HILLSLOPE SEEPS (CONTD)	
Wetland type	**B Minor and major hillslope seeps south of the Oyster Bay dunefields** – these include the **Langefonteinvlei**
Examples • Langefonteinvlei • Hillslope seeps between Langefonteinvlei and the Oyster Bay dunefield	 **Photo G** **Mosaic habitat in the Langefonteinvlei wetland**
Data prefix	HS (e.g. HS-Lang = Langefonteinvlei
Extent on site	These wetlands are located between the two mobile dunefields – the Oyster Bay and Thysbaai dunefields. The smaller examples of this wetland type predominate on the southern slopes of the Oyster Bay dunefield, where they comprise west-east aligned bands of shallow, seasonally saturated wetland. The **Langefonteinvlei** is the largest single wetland on the Thyspunt site, and comprises two distinct portions – a larger, northern portion and a somewhat smaller, but similarly structured southern portion (Figure 2.6). The Langefonteinvlei comprises mainly densely vegetated, permanently saturated wetland, which forms a mosaic habitat with patches of slightly drier wetland, shallowly inundated depressions and a braided system of shallow trickle surface flow across a thick layer of organic material (>4m in depth). This organic layer probably plays a role in reducing infiltration into the sandy underlying aquifer, leading to a self-perpetuating cycle of increased water retention in the wetland, which encourages the establishment and maintenance of the dense permanent wetland vegetation that characterises this valley bottom wetland. Water stored in the organic layer is also likely to play a role in maintaining vegetation typical of permanently saturated conditions, through periods of drought (Visser *et al.* 2011).
Botanical characteristics Note Low (2009) provides full descriptions and analyses of wetland flora at this site and only dominant species or those of particular interest are listed here	Most of the wetland in terms of area is dominated by dense stands of *Cladium mariscus,* believed to be critically important in terms of overall wetland function, as they are likely to play a role in slowing down the rate of passage of water through the wetland, thus maintaining the constant trickle flow through the lower reaches of the system as well as retaining water in root / soil complexes and in resisting erosion during flood periods, when high water simply flows over the tops of these plants. Slightly higher-lying or marginal areas are more structurally diverse, comprising either mixed sedges (mainly *Juncus* kraussii and *Carex*

	sp.) or stands of *Cyperus thunbergii* and *Carex mariscus*. The drier wetland margins, which give way to terrestrial vegetation, include patches of mixed *Senecio helimifolius*, and *Psoralea* sp. In the upper (eastern) portion of the Langefonteinvlei, the water table appears to lie just beneath, rather than at, the surface, and these slightly drier conditions have led to the establishment here of dense areas of mixed *Phragmites australis* and *Psoralea* sp., which merge with the wetter system further downstream. Low (2009) described the wetland as characterised by two sub-communities, with key species in the first comprising *Cladium mariscus*, *Helichrysum cymosum*, *Nidorella auriculata*, *Senecio helimifolius*, *Solanum africanum* and *Thelypteris confluens*, while those in the second community comprised *Chironia peduncularis, Helichrysum cymosum*, *Mentha aquatica*, *Neesenbeckia punctoria*, *Senecio helimifolius* and *Thelypteris confluens*. Low (2009) identified 56 plant species in the Langefonteinvlei (none of which were Red Data species. The smaller hillslope seeps shown in Figure 2.6 are vegetated by patches of mixed *Juncus capensis, Juncus kraussii*, *Cyperus thunbergii* and, in wetter areas, isolated patches of *Typha capensis* and dense stands of *Cladium mariscus* and *Psoralea* spp.
Physico chemical characteristics	Physical and chemical data for the Langefonteinvlei allowed for superficial characterisation of this system as of being of neutral pH, with fresh water (measured EC of 74.7 mS/m), negligible concentrations of nitrogen, and phosphorus concentrations that suggest that the wetland is mesotrophic. Most of the phosphorus is in the form of biologically available soluble reactive phosphorus. Wetland water quality appears to be calcium-sodium-chloride dominated (Figure 2.7), with relatively high sulphate concentrations too, consistent with the presence of large volumes of decaying organic matter under anaerobic conditions (Kadlec and Knight 1996).
Aquatic invertebrates	The shallow (<5cm deep) trickle flows through the Langefonteinvlei wetland meant that the availability of open water aquatic habitat was fairly limited in this large system and aquatic invertebrates were not collected. The wetland is however likely to support communities of invertebrates including Odonata (limited by the paucity of open water habitat), as well as small invertebrates (e.g. ostracods), sediment-dwelling taxa (e.g. chironomids) and crabs (observed but not identified in this study), which are all probably abundant in the main wetland.
Other wetland fauna Detailed descriptions of fauna associated with the seeps is provided in Harrison et al. (2009)	The size of the Langefonteinvlei is such that despite low levels of local impacts (see below), the wetland area clearly supports a substantial (but unquantified) faunal community. Otter scat, porcupine and bush pig diggings, mongoose footprints and footprints belonging to a medium sized member of the cat family were all found within a relatively small area of the wetland, suggesting that the wetland, along with the adjacent terrestrial habitat, supports a relatively complex food web. During the September 2009 site visit, the Elandsberg Dwarf Chameleon *Bradypodiun taeniabronchum* was found in the wetland, representing an entirely new locality for this species (J. Harrison,

	faunal specialist, pers. comm.). *B. taeniabronchum* is described by as Critically Endangered, as a result of its small distribution and loss of habitat in these areas (Tolley and Burger 2007).
Source(s) of water	The wetland is primarily groundwater-fed, with water from the Algoa Aquifer daylighting into the mid-eastern and northern sections of the wetland, as surface trickle flows. The northern portion of the wetland is believed to be in contact with the underlying water table, while the southern section is perched above the water table. A thick layer of organic sediment retains moisture across the wetland, and moreover forms a relatively impermeable barrier to surface flows from upstream portions of the seep, which follow the surface topography, flowing both west and south across the wetland. These flows dissipate with movement downstream, as a result of evapotranspiration and/or natural dissipation into the dune sands downstream of the thick organic layer.
Links with other wetland ecosystems	The Langefonteinvlei forms part of a longitudinal band of hillslope seeps and unchannelled valley bottom wetlands, with high ecological value as an east-west corridor through increasingly developed areas to the east of the Thyspunt site.
Impacts	The Langefonteinvlei is considered largely unimpacted. Minor sources of impact include abstraction from the spring area, to supply local residents with water for domestic use. Other impacts include crossing of the upper portion of the wetland by tracks, and invasion along its edges by woody alien vegetation.
Occurrence of wetland type in the broader region	Although permanently saturated, vegetated hillslope seep wetlands do occur in interdunal areas elsewhere, the size of the Langefonteinvlei and its location with respect to other wetland habitat types (the duneslack wetlands of the Oyster Bay dunefields) has resulted in it being regarded as a one-of-a-kind system.
Key uncertainties	Uncertainty still exists regarding details of the natural hydroperiod and inundation cycles of the Langefonteinvlei – longer term data are required to provide information regarding these aspects.
Key sensitivities	The hillslope wetlands are likely to be particularly sensitive to impacts that result in concentrations of flow through the wetlands; reductions in flow passing through the wetlands; increases or decreases in water table, such that they change wetland habitat quality.

2 PERMANENTLY TO SEASONALLY SATURATED HILLSLOPE SEEPS (CONTD)	
Wetland type	**C. Hillslope seeps** within the largely agricultural area to the north of the Oyster Bay dunefield
NOTE: These are described along with the valley bottom wetlands from the same area	

3 PERMANENTLY TO SEASONALLY SATURATED VALLEY BOTTOM WETLANDS	
Wetland type	**A. Valley bottom wetlands north of the Oyster Bay dunefield – naturally unchannelled and artificially channelled** These occur in conjunction with extensive **hillslope seeps (C, above)** within the largely agricultural area north of the dunefield NOTE: both wetland types discussed together in this section.
Wetlands occurring in the panhandle area on the Eskom site Photo H Pennysands River – an unchannelled valley bottom wetland that passes into the Oyster Bay dunefield within the "panhandle" area Photo I Depression at the downstream end of a hillslope seep in the "panhandle" – feeding into the Pennysands River	
Data prefix	HS or VB
Extent on site	Both wetlands shown in the photographs above occur on the Eskom site, in the panhandle area, and are fed by substantial hillslope seeps, which pass through agricultural development (mainly cattle grazing and wheatland) upstream of the depression shown in Photo I. The main seep feeding the Pennysands River (and by implication the depression wetlands located along the northern edge of the dunefields) rises to the east of the Eskom site boundaries. Smaller, highly impacted hillslope seeps and a valley bottom wetland occur on the Farm Welgelegen, to the west of the Eskom site. Numerous ponds / dams have been constructed on hillslope seeps on farms to both the west and east of the site, and to a lesser extent on the site itself.
Botanical characteristics Note Low (2009) provides full descriptions and analyses of wetland flora at this site and only dominant species or those of particular interest are listed here	The disturbed hillslope seep and valley bottom wetlands associated with the Pennysands River lie in Low (2009)'s Sandstone Fynbos plant community, and are located on sandstone alluvium. Key species include *Berula erecta* subsp. *thunbergii*, *Carex* cf. a*ethiopica, Cyperus thunbergii*, *Hydrocotyle verticillata* and the alien grass *Pennisetum clandestinum*. A moderate total number of species were found (35) including one Red Data species (Low 2009). The valley bottom is however subject to high levels of invasion by woody alien

	vegetation (mainly *Acacia saligna*), all along its edges as far as the start of the dunefield, when the alien vegetation is reduced. The wetland depression (marked X in Figure 2.6) at the upstream end of the Pennysands valley bottom comprises a relatively diverse system, with stands of *Cladium mariscus*, *Cyperus thunbergii* and *Amaranthes* sp. A small trench along the southern edge of the wetland result in drainage of local wetland areas, and creates habitat for species that thrive in disturbed shallowly inundated conditions, such as *Typha capensis,*
Physico-chemical characteristics	Water quality samples from this site were unfortunately compromised at the laboratory, and no detailed water quality data are available. *In situ* EC data indicated fresh water (65 to 76 mS/m on the Pennysands River). Both the depression (x) and the Pennysands River / valley bottom wetland were characterised deep and highly organic substratum. In the case of the depression, this layer was saturated at 80 cm; the river channel itself comprised trickle flow over the organic mud, which was saturated to the surface. Decay of fynbos vegetation in the broader area, and its subsequent leaching into streams by way of groundwater movements, may underlie the darker tannin-stained waters that characterise the wetlands on the north-western end of the dunefield, in the vicinity of the panhandle and immediately west of the Eskom boundary. Groundwater data from the hydrocensus undertaken by SRK as part of their EIA study showed that groundwater in boreholes just north of the Pennysands River depression had pH values between 5.9 and 6.7, and EC values between 78.9 and 55 mS/m (Sites Strydom3, Strydom4 and Pennysands1). These data, showing slightly acidic groundwater, consistent with a sandstone fynbos botanical area, support the suggestion that the black water systems that occur along the western section of the northern dune edge derive from humic acids from inflowing groundwater.
Aquatic invertebrates	Invertebrates were not sampled from these systems – insufficient standing water habitat was available.
Other wetland fauna Descriptions of fauna associated with the broader wetland habitats in this portion of the site is provided in Harrison et al. (2009)	South of the depressional wetland "x", it is probable that the dense plant cover that occurs within and around the Pennysands valley bottom wetland, coupled with the distance from areas of human disturbance and the association of the wetland with fresh water, must make the wetlands in this area attractive habitats for small mammals, including antelope, porcupines, bush pig, otters and mongooses. The valley bottoms are also likely to serve as useful longitudinal corridors, linking to the main dunefield and its wetlands. The wetlands to the north of wetland "x" are disturbed and in the close proximity of human activity. It is assumed that their faunal value lies mostly in their provision of habitat for much smaller wetland fauna, such as frogs and aquatic invertebrates, during periods of inundation.
Source(s) of water	Valley bottom wetlands are assumed to be fed primarily by the hillslope seeps as well as by direct precipitation. The hillslope seeps are believed to represent a combination of springs (presumably

	linked to exposures of groundwater through fractures in the unweathered quartzites) and groundwater day-lighting of subsurface through-flows in areas where the underlying rock intersects the surface. The fact that the lower Pennysands River flows even during dry periods suggests some groundwater link – the underlying aquifer in this area is the unconfined Algoa aquifer. Data from SRK's hydrocensus indicate that boreholes in the close vicinity of the Pennysands River had water close to the surface – (0.87 to 0.35 mbgl).
Occurrence of wetland type in the broader region	The largely seasonal hillslope seeps and valley bottom wetlands mapped to the north of the dunefields, mainly in the so-called panhandle area, are common drainage features in the surrounding area.
Special attributes	Upstream of the depressional area "x", which really marks the start of the more sandy dunefield edge, the wetlands are generally degraded – only a portion of the hillslope seep running immediately east of the panhandle, and feeding into depression x retained significant areas of indigenous vegetation. The wetlands feeding into the dunefield are however of importance for their contribution to the hydrology of the extensive depressional wetlands that occur along the northern dune edge. Rehabilitation of wetland integrity along the hillslope seeps would potentially improve water quality passing into downstream areas and reduce erosion.
Key uncertainties	Uncertainty exists regarding the role of these wetlands with regard to recharge of the Algoa aquifer in the dunefield area – site visits indicate that recharge does occur along the northern dune edge, particularly in the area adjacent to the panhandle. Some of this water perches temporarily, forming surface wetlands, while the rest infiltrates into the dunes, and may re-emerge elsewhere, where the water table is intercepted by low points or where dune movement results in the exposure of perched water within the dune. Surface and groundwater data are limited for this area.
Key sensitivities	The wetlands would be sensitive to receipt of concentrated flow; channelisation; loss of existing flows; infilling and further physical disturbance.

3 PERMANENTLY TO SEASONALLY SATURATED VALLEY BOTTOM WETLANDS (CONTD)	
Wetland type	**B Unchannelled valley bottom wetlands** (area between the two main mobile dune fields, south of the Oyster Bay dunefield)
Examples Least-impacted section of Eastern Valley Bottom Wetland just east of the Langefonteinvlei. Most of this wetland is densely invaded by alien vegetation (mainly *Acacia saligna*)	
Data prefix	VB-east
Extent	Unchannelled valley bottom wetlands are the dominant wetland type south of the high dunes of the Oyster Bay dunefield and east of the "watershed" at Langefonteinvlei. The main unchannelled valley bottom wetland in this area is referred to in this report as the Eastern valley bottom wetland, and flows from a point just east of the Langefonteinvlei, towards St. Francis Bay (see Section 2.3.3). Most of these wetlands lie outside of the present owner controlled Eskom boundary, but do lie in close proximity to the proposed (eastern) access road to the site (see Section 3). The valley bottom wetlands east of the Langefonteinvlei (and east of the Thyspunt site itself) have been highly invaded by woody alien vegetation, making their exact demarcation difficult, although they appear to have formed in the low lying depressions between the two main lines of parallel mobile dunes shown in Figure 2.6. The woody vegetation has probably also resulted in shrinkage of the margins of these wetlands, which are likely to expand once alien removal takes place.
Botanical characteristics	These wetlands, which lie beyond the Thyspunt site boundaries, fell outside of Low (2009)'s detailed study area, and were broadly included in his assessment of the Langefonteinvlei wetland. The dominant plant community was similar, however, with stands of *Cladium Mariscus* in wetter areas, and *Helichrysum cymosum*, *Nidorella auriculata*, *Senecio helimifolius*, *Solanum africanum* and *Thelypteris confluens* along the saturated to damp margins.
Physico chemical characteristics	The once-off water quality sample for this wetland indicated water that was sodium-chloride dominated, with relatively high calcium, and slightly elevated sulphate – the latter probably consistent with the accumulation and breakdown of plant material in a wetland system.

Aquatic invertebrates	Unlike the duneslack wetlands, these wetlands were dominated in terms of number of individuals by baetid ephemeropterans (*Cloeon* sp.) (Table 2.7), with only low numbers of other taxa being found. Dipteran taxa (specifically larvae of the chironomid *Polypedilum* sp) were also present in relatively large numbers, and appear to thrive on the organic detritus of this habitat. Altogether, a total of 25 invertebrate taxa were identified in the sample. Of these, there were fewer crustacean taxa in this habitat than in the duneslack habitats m,n already described, and neither cladocerans nor Calanoid copepods were found in the habitat at all. Instead, the invertebrate community was more characteristic of pond habitat, with low numbers of individuals contributing to a relatively diverse group of benthic fauna. Hemipteran taxa were also well-represented (typical of standing water habitat). Only three odonate taxa were identified (nymphs of an aeshnid dragonfly assumed to be *Aeshna subpupillata* as well as several coenagrionid and lestid damselfly nymphs, which probably occurred in wetland vegetation overhanging the aquatic margins).
Source(s) of water	These valley bottom wetlands are believed to be mainly groundwater fed systems, receiving water as seepage from the base of the high dunes as well as themselves reflecting day-lighting of the water table in the intergranular aquifer.
Links to other habitats	At present, the valley bottom wetlands provide a continuous corridor from the western edge of the Links Golf course through to the Eskom site, thus connecting to the broad habitat types presently preserved on the site, and including the high dunes, the coastal seeps and the Langefonteinvlei. As development of the area east of the Eskom boundary increases, the importance of these wetlands as a protected habitat and corridor for the movement of wetland as well as terrestrial fauna is likely to increase.
Occurrence of wetland type in the broader region	See below
Special attributes	The Eastern Valley Bottom Wetland lies wholly off the existing Eskom site. Despite its level of impact, the system is considered regionally and locally rare, and derived largely from its context in the valley bottom between two major dunefields, with a substantial groundwater influence. Given removal of alien vegetation, recovery of wetland vegetation along the valley bottom wetlands is likely to be rapid.
Key sensitivities	Expanding resort development and peri-urban settlements are taking place rapidly along the length of the wetlands to the east of the Thyspunt site, with cluster development within close proximity of wetlands, roads constructed through wetlands, infilling, drainage, diversion of flows and large-scale fragmentation all considered to be having an increasing level of impact on the system downstream of the Thyspunt site boundary. Flow from the wetlands has been diverted past the Links golf course, towards the Sand River. This section is thus vulnerable to increases in upstream flows, beyond the capacity of the system into which they have been diverted.

	Dune geomorphology models such as that proposed by Prof Ellery (Rhodes University) and discussed briefly in Section 2.3.7, suggest that the dunes have a natural tendency towards episodic water-driven movement of sand along the eastern section dunefields – the impacts of such events would be exacerbated by diversion of natural flow pathways.

Based on the summary information provided in the table above, regarding each of the major wetland types described for the site, the following broad geographical categorisations can be made of the Thyspunt site, relating wetland type to areas within and immediately adjacent to the site:

- **The coastal area**, roughly defined by the 200m coastal setback line, but extending an additional 325m southwards in the vicinity of the mapped major coastal seep demarcated with an asterisk (*) in Figure 2.6 – this area includes the coastal seeps described in Table 2.8
- The **low-lying area between the major Oyster Bay dunefield and the Thysbaai dunefield**, including the Langefonteinvlei hillslope seep, the Eastern Valley Bottom Wetland and numerous minor hillslope seeps south of the Oyster Bay dunefield
- The **Oyster Bay dunefield**, including the duneslack wetlands / depressional wetlands mapped in Figure 2.6, and including the depressional wetlands along the northern edge of the dunefield
- The **agricultural area to the north of the Oyster Bay dunefield**, including the seasonally inundated to saturated, channelled and unchannelled valley bottom wetlands and hillslope seeps identified in this area, as far as their interface with the low-lying depressional wetlands on the northern edge of the Oyster Bay dunefield itself.

2.3.8 Assessment of Present Ecological Status (PES) of wetlands on and associated with the Thyspunt site

The PES methodology (DWAF 1999) was used to derive overall PES scores for similarly impacted wetland types on and associated with the site. Each of the wetland types described in Table 2.8 was assessed separately, using this methodology.

The WET-Health (Level 2) methodology was used to determine Health Classes that are compatible with those derived from the PES assessments, for the two largest wetland systems associated with the site – that is, the Langefonteinvlei system and the extent of valley bottom wetland that extends from the Langefonteinvlei eastwards, towards The Links golf course on the outskirts of St. Francis Bay (Figure 2.6). These wetlands were assessed in terms of two of the WET-Health modules for these wetlands, namely the hydrological and the vegetation modules.

WET-Health assessment

The two HGM units for which WET-Health assessments were carried out comprised the Langefonteinvlei hillslope seep and the Eastern Valley Bottom wetland. It should be noted that these HGM units are not hydrologically connected and were thus treated as two discrete catchments, with areas of approximately 36.7 and 64.3 ha respectively. The units were mapped at a broad scale. Access to the Eastern Valley Bottom wetlands was limited by the extensive alien invasion there, and the system was assessed primarily by means of aerial photography, with limited ground-truthing of the assessment undertaken at accessible locations. Of the two HGM units, the eastern wetland system is highly invaded by woody alien vegetation (mainly *Acacia cyclops)* while the Langefonteinvlei has little alien vegetation, but is impacted at a local scale by the activities of local residents.

In the Eastern Valley Bottom wetland HGM unit, assessment of both the Vegetation module and the Hydrology module for WET-Health resulted in assignments of Wetland Health Category D for this system. In terms of wetland hydrology, the main impacts driving this categorisation were associated with extensive invasion of the HGM unit by woody aliens, resulting in impacts to flows. Similarly, in terms of the Vegetation module, the main impact in terms of vegetation was the extensive alien invasion. Invasion by woody alien species occurred throughout the system, while invasion by weedy species or so-called garden escapees was limited to the downstream portions of the HGM unit, which are encroached upon by residential developments. Associated with these are impacts such as the spread of kikuyu grass (*Pennisetum clandestinum*) and various weedy invaders, which capitalise on disturbed areas.

The WET-Health assessment of the Langefonteinvlei, by contrast, resulted in an assignment of Health Category A for both hydrology and vegetation modules. The limited abstraction and patchy invasion by alien vegetation along the wetland margins did not impact significantly on the calculated Health scores for this system.

PES using DWAF (1999)

The PES methodology, adapted from DWAF (1999) was used to derive a simplified, overview assessment of wetland Present Ecological Status for each of the wetland types identified in Sections 2.3.4 - 2.3.7. Assessment of wetlands by type is permissible in this case, given that wetlands within each group on the site as a whole are affected by a similar range and level of impacts. The exception to this is found in the hillslope seep wetlands, which have been differentiated in terms of broad levels of impact / land use, as well as in terms of size and hydroperiod, with large, permanently saturated to inundated wetlands being assessed separately to smaller, seasonally inundated to saturated systems. PES assessments have been made for each of the following wetland groupings:

Seasonal duneslack wetlands: these wetlands were allocated a PES Category of A, reflecting a largely unmodified, near-natural condition – the only impact category scored below "natural" related to terrestrial encroachment by woody alien vegetation.

Hillslope seep wetlands (south of the Oyster Bay dunefield):

- Langefonteinvlei: this wetland and the smaller adjacent system to the south were assessed as having PES category A, with all rated criteria scored as natural or near natural
- minor, seasonally saturated hillslope seeps: these wetlands were assessed as a PES Category B. Most criteria were allocated scores of 4 (assuming natural to near-natural condition) with a minimum scores of 3 allocated for the following criteria: terrestrial encroachment (leading to wetland desiccation); loss of fringing vegetation; invasive plant encroachment and the presence of minor roads alongside these systems.

Unchannelled valley bottom wetlands – south of the Oyster Bay dunefield

- the Eastern valley bottom wetland – permanently saturated wetlands, invaded by woody alien vegetation: these wetlands were assessed as PES Category C (moderately modified with some loss of habitat). Low scoring PES criteria included changes in shoreline or transitional fringing vegetation as a result of landuse practices and alien invasion (scored 2); terrestrial encroachment as a result of alien invasion (scored 1) and flow modification as a result of alien invasion (scored 2). The other criteria were all scored as 4 – that is, assumed to be in a natural or very near-natural condition.

Coastal seeps: these systems were assessed as a PES Category A – they are considered presently unimpacted within the Thyspunt site; and

Valley bottom wetlands and hillslope seeps in agricultural areas: these areas, mapped in Figure 2.6, were assessed as having a PES of Category C (lower). All criteria were rated between 2 and 3, indicating the extent of degradation of wetland habitat as a result of agricultural activities, including channelisation, grazing, nutrient enrichment, erosion, alien invasion and changes in faunal communities as a result of human proximity.

2.3.9 Comments on wetland sensitivity

- The relatively unimpacted nature of most of the wetlands on the Thyspunt site means that they could show significant response to even minor disturbance, resulting in a shift of PES to a lower class. Changes in water quality, flow rate or hydroperiod would all be considered potential sources of disturbance to these systems.
- The duneslack wetlands, coastal seeps and permanently vegetated hillslope seeps and valley bottom wetlands north of the Oyster Bay dunefield are likely to be particularly sensitive to any physical disturbance that alters surface or groundwater flow on which these systems rely. Short-term disturbance in the form of a change in flow or water supply is likely to result in a lower level of impact than long-term disturbance, in that recovery should occur in the former scenario.
- The hillslope seeps and valley bottom wetlands are also likely to be susceptible to any unnatural increases in flow regime that resulted in concentration of flows and erosion, particularly headcut erosion.
- Since the southern and south-western portions of the Langefonteinvlei are considered to be perched above the groundwater table of the Algoa Aquifer, abstraction of groundwater that extended to these portions of the wetland would not have an effect on wetland function (Visser *et al*. 2011).
- Any groundwater abstraction that extended to the northern and eastern portions of the wetland would have potentially dire consequences for wetland function, particularly in the long term (Visser *et al*. 2011).
- The exact zone where the wetlands shift between direct and indirect links to groundwater is likely to vary between wet and dry periods (Visser *et al.* 2011).
- All of the wetlands are likely to be sensitive to changes in water quality, including increases in salinity.
- The already-disturbed valley bottom wetlands north of the Oyster Bay dunefield would still be sensitive to diversion of flows, infilling and channelisation, as well as changes in water quality (e.g. salinity increases or prolonged nutrient enrichment) and increases in flow velocities leading to erosion and down cutting. Hardening of surfaces in this area would be a potential source of such impacts.

2.3.10 Assessment of Wetland Ecological Importance and Sensitivity (EIS)

Using the EIS protocol outlined in Section 1.4.5, and based on the comments provided in Sections 2.3.8. 2.3.9 and 2.3.10, importance and sensitivity classes were assigned to the groups of wetlands on and near the Thyspunt site, as differentiated for the DWAF (1999) PES assessment in Section 2.3.8.

The seasonal duneslack wetlands were allocated an EIS Importance Class A (very important), based on their:

- provision of habitat for rare wetland species;
- high level of habitat and species richness;
- provision of a unique habitat type;
- high sensitivity to changes in patterns of inundation, discharge rates, water quality and disturbance;
- groundwater discharge to downstream systems; and
- extreme importance for conservation as components of a unique natural system.

As a result of the low confidence at present in conceptual models of hydrological linkages between the depressional areas and surface and groundwater flows, a conservative approach was taken to this assessment, and it was assumed that the wetlands have potential high sensitivity to changes in groundwater hydrology.

EIS ratings were allocated as follows:

Hillslope seeps south of the Oyster Bay dunefield:

- the Langefonteinvlei was allocated an EIS Importance Class A, based on its provision of an extensive and unique habitat type, its links to adjacent wetland systems and its importance for conservation and research; and
- minor, seasonally saturated hillslope seep wetlands were allocated an EIS Class B on the basis of their provision of wetland habitat contributing in places to species richness, their sensitivity to changes in hydrology, hydroperiod, discharge and water quality.

Unchannelled valley bottom wetlands south of the Oyster Bay dunefield

- the eastern, permanently saturated valley bottom wetlands were allocated an EIS class B, on the basis of their existing, but impermanent impacts (alien removal will address most of the impacts afflicting these wetlands), their provision of wetland habitat contributing in places to species richness and their importance in terms of hydraulic buffering and groundwater recharge

Coastal seeps: these systems were allocated an EIS Class of A, based largely on their:

- high level of habitat richness;
- provision of a threatened and rare habitat (e.g. freshwater seeps in the coastal area); and
- sensitivity to changes in hydrology and patterns of inundation (including sea level rise) and rates.

Hillslope seeps and valley bottom wetlands in agricultural areas: these wetlands were allocated an EIS Class of C, based on their:

- provision of small areas of habitat and species richness;
- provision of limited elements of habitat that has become fragmented by agricultural development and infrastructure;
- moderate sensitivity to changes in hydrology, patterns of inundation, discharge rates and/or human disturbance; and
- limited level of water quality enhancement.

2.3.11 Implications of the baseline wetland assessment for future developments:

Based on the characteristics of the wetlands on the Thyspunt site, the following points should be regarded as important red flags with implications for future development of the site, if such development is to avoid significant impacts to wetland systems.

- The following wetland systems should be regarded as of high sensitivity and very high conservation importance, and should be protected from any form of future degradation, or the risk of degradation:

- The duneslack depressions on the Oyster Bay dune field
- The duneslack depressions along the northern edge of the Oyster Bay dunefield
- The coastal seeps
- The Langefonteinvlei (northern and southern sections).

Protection of the above systems requires that:

- The groundwater systems on which these wetland rely remain intact, and there is no change in the quality, timing or magnitude of water supply to these wetlands;
- There is no change in the resilience of groundwater systems to continue to support the identified wetlands – that is, groundwater systems should not be stressed to a level where it becomes likely that in times of water stress they will no longer be able to meet ecosystems demands that are currently quite adequately , even in times of drought;
- There is no change in surface hydrology, such that concentration of flow occurs into some wetlands, resulting in erosion, while other wetlands (or the same wetlands at different times) are potentially deprived of flow;
- Supporting ecosystems (e.g. surrounding terrestrial areas, including the coastal forests and the dunefields) are actively conserved, so that corridors between habitats are protected and to ensure that the wetland do not act as isolated units, but as an integrated part of the natural landscape; and
- Adequate setbacks are set in place, over and above those required to ensure the above requirements, to allow for physical separation of developed areas from conservation areas – minimum setbacks of 220m from the edge of the Langefonteinvlei and the coastal seeps are recommended, to reduce impacts such as noise, human activity and the spread of weedy or other alien plant material into these wetlands. **It must be stressed however that such setbacks are likely to be superseded by measures that address the need for protection of the groundwater systems that sustain these wetlands, and that surface setbacks on their own will not provide protection for these groundwater-fed systems**

The following wetland systems should be regarded as of medium to high conservation importance, primarily for their role in conveyance of water to the dunes, and the wetlands along the northern edge of the dune system, including the Pennysands River from immediately upstream of the depressional wetland (demarcated as “x” in Figure 2.6):

- Hillslope seep wetlands north of depression “x” on the Pennysands River
- Valley bottom wetlands north of depression “x” on the Pennysands River.

The Eastern Valley Bottom wetlands (immediately east of Langefonteinvlei) should be regarded as wetlands of very high conservation importance, representing regionally rare wetland habitats. They are highly threatened by current and proposed developments. Their conservation requires the following treatment as a minimum:

- Rehabilitation of wetland habitat through alien clearing;
- Protection of the groundwater resources that feed these wetlands;
- Imposition of adequate setback areas for developments, that will allow these broad wetlands to retain their east-west longitudinal connectivity to the Langefonteinvlei, as well as north-south connectivity to the dunes on either side of them;
- Management of surface flows from hardened surfaces so as to minimise impacts to the valley bottom wetlands – activities resulting in channelisation of flows would be particularly detrimental to the integrity of these systems.

3 DESCRIPTION OF KEY ACTIVITIES ASSOCIATED WITH THE PROPOSED DEVELOPMENT

3.1 Overview

This EIA report considers the implications for freshwater ecosystems of the development of a single nuclear power station (NPS) capable of generating up to 4000MW, along with some of the site-specific developments that would be associated with its construction or operational phases, such as access roads, sewage and water treatment plants, administration buildings and internal infrastructure. Note however that the EIA does not consider the impacts of transmission lines outside the boundaries of the sites, neither does it assess indirect impacts to freshwater systems associated with the influx of temporary and permanent personnel into the areas within the vicinity of the proposed nuclear sites – e.g. accommodation; off-site sewage and water requirements. These limitations are discussed in Section 1.3.2.

3.2 Description of layouts

The information provided in these sections has been sourced primarily from Eskom (2008a, b and c). Additional references have been included where relevant.

3.2.1 Layouts

Figures 3.1, 3.2 and 3.3 show the conceptual layout of a Nuclear 1 development at each of the three sites (Duynefontein, Bantamsklip and Thyspunt). The figures shown do not specify actual locations or footprints for the proposed nuclear plants, their associated infrastructure and ancillary buildings. Each of the figures indicates instead the conceptual terrace size for a single plant of capacity 4000 MW, which would be located, if approved, somewhere within the broad corridor described in the figures as "corridor for nuclear plant and auxiliary buildings". Similarly, the figures give conceptual footprints for the topsoil and spoil stockpiles, that would need to be accommodated somewhere on site, or disposed of elsewhere.

In broad concept, the development of each nuclear plant would entail:

- Construction of one or more nuclear "islands" in which the nuclear reactors would be housed. These would be constructed some 10 – 15m below bedrock and, assuming bedrock is at mean sea level, would stand up to 70 m amsl (Eskom Plan and Section Rev. B- 2008 /06/18);
- Construction of turbine buildings;
- A marine intake of cooling water, pumped to the turbine buildings along an intake tunnel;
- Distribution of cooling water from the intake system to the turbine buildings, along a canal or pipe; and

- Discharge of heated cooling water back to the sea, through a piped outfall.

3.2.2 Setbacks and boundaries

The proposed layouts all allow for a 200m setback from the coast, in order to reduce corrosion impacts. The NPS terrace would be fenced with high security electrified fencing. Off-terrace facilities would also be fenced by a low security fence and the boundaries of the sites (that is, the “owner controlled boundary” of each site) would be fenced with low cost fencing, with specifications similar to that of a game fence (Eskom 2008a-c).

3.2.3 Sewage disposal or treatment

Provision of on-site treatment has been proposed at all sites. A sewer network would gravity-feed sewage to a sump, likely to be located on the seaward (i.e. down-slope side) of the proposed terrace. From here, sewage would be pumped to the proposed WWTW (Eskom 2008a-c). The use of an anaerobic treatment package plant on each site is the preferred approach to sewage treatment at each site (Eskom Project Management written comment to earlier draft of this report). Such an approach would not be associated with evaporation ponds.

Although Eskom 2008 (c) suggested that, in the case of the Thyspunt site, building a proper sewage works at Oyster Bay might be considered, this aspect has not been assessed in this report, and would require detailed assessment if it were to be considered in the future. The present report thus assesses only the proposed on-site treatment of sewage generated on site.

3.2.4 Fresh water supply

A number of alternative sources of water have been considered, namely:

- Metropolitan or other municipal water supply:
    - Duynefontein: water from the City of Cape Town’s metropolitan supply system could be accessed by pipeline
    - Bantamsklip: the Breede River is the closest external water source – its use would require licensing from the Department of Water and Environmental Affairs. No capacity exists for the supply of water from municipal water supply systems.
    - Thyspunt: water for this site could be drawn off the municipal feeder main at St Francis Bay, and piped along the proposed access road to the site.
- Desalination by reverse osmosis – this is the preferred fresh water supply option for all three sites and would require:
    - 20 m^3 diesel storage;
    - a standby generator;
    - intake and out-take zones:
        - during construction, beach wells would supply water, brine would be discharged to the breaker zone. During the operational phase, intake water would be drawn off the Cooling Water intake canals and the brine would be discharged via the cooling water outlet system;
        - during construction, treated water would be stored in a temporary lined pond; during the operation phase, it would be stored in potable water storage tanks;
    - effluent from reverse washings would be disposed of in a “neutralisation pit”;

  - during the operational phase, three units would be in use.
- Aquifer water:
  - Duynefontein: the Aquarius well-field is located 6km north-east of Duynefontein – it is currently not used to supply Koeberg because of poor water quality;
  - Bantamsklip: aquifer water is not considered as a freshwater supply source at this site;
  - Thyspunt: the aquifers underlying the site, as well as a number of licensed boreholes off-site are being considered.

During construction, fresh water would be required for:
- Manufacture of concrete
- Earthworks
- Dust suppression
- Potable water.

During the operation phase, fresh water would be required for:
- Input to the demineralised water plant;
- Input to plant processes;
- Fire water; and
- Potable water.

3.2.5 Stormwater management

All of the sites allow for separation of contaminated (with oils, fuel etc) stormwater from "clean" stormwater. The latter would be discharged into the sea while the former would be processed in a containment pond, with polluted material being disposed of off-site and clean, processed water being disposed of to sea, recirculated or pumped to an evaporation pond.

3.2.6 Dewatering

Draw-down of groundwater would be required during excavation at all three sites – Eskom (2008a) estimates a 346-day period for dewatering.

Some engineering measures to limit the effect of draw-down on ground water dependent ecosystems and other users would be likely to be implemented.

3.2.7 Disposal of spoil

All three construction sites would generate large volumes of spoil, which would need to be disposed of either off-site or on-site. The following methods of disposal of spoil are considered feasible:
- Removal to a dump site in the vicinity of the construction site; and
- Hydraulic pumping out to sea.

In the case of Thyspunt, the following additional measures for the disposal of fill were initially considered:
- Removal of spoil to the "panhandle", and its use in construction of a terrace – the sand could be transported via a temporary open conveyor system or trucked there by road;
- Dumping of spoil on a sand dune in the Oyster Bay dunefield;
- Dumping the spoil on the beach at Thyspunt, to build up the beach; and

- Hydraulic pumping of sand to St. Francis Bay beach for the rebuilding of the beach – that is, pumping the sand through a pipeline along the low lying areas between the site and Cape St. Francis (that is, along the valley bottom wetlands east of the site)
- Disposal of spoil at sea.

Of these options, only removal of spoil to the “panhandle” by conveyor system, and disposal of spoil by pumping out to sea are still considered potentially viable options, and assessed in this report.

Figures 3.1 to 3.3 indicate the approximate sizes of the topsoil and spoil stockpiles that would be generated at each of the proposed Nuclear 1 sites.

3.2.8 Terrace Roads

Internal roads connecting administrative buildings, the NPS and other buildings on the site to each other and to the proposed external access roads would be required. The details of these have not been provided. It is assumed that their alignments would be finalised once the position of the NPS on the approved site(s) has been finalised.

3.2.9 Provision of a power supply during construction

Various combinations of 22kV, 66kV, 132kV and 400kV power supplies would be used at any of the selected sites during its construction and commissioning phases.

At the EIA specialist integration meeting held in November 2009, it was confirmed by Eskom engineers that a 132kV line would be used at Thyspunt. The proposed alignment of this line would follow that of the transmission lines, described in Section 3.4.2 – that is, across the mobile Oyster Bay dunefield, to the site of the proposed HV yard on the panhandle (Figure 3.3).

A single 132 kV distribution line would be required, with pylons typically 40m high, with spans between pylons of around 400 m.

3.3 Associated off-site development

3.3.1 Access roads

Thyspunt: Two access roads are proposed, comprising:

- An access road from the east that turns off the R330 in the vicinity of Sea Vista – the alignment of this road, developed during an iterative process with the botanical, heritage, wetland and traffic specialists is shown in Figure 3.4 (“eastern access”). This road would be designed to carry the super load vehicles and be used for transportation of heavy load plant items; and
- Two alternative routes have been proposed to allow access from the west / north of the site. The selected road, if approved, would be designed for access to the site for construction vehicles and power station personnel but would not be used for the transportation of the heavy load plant items. The alternative routes, labelled “western” and “northern” in Figure 3.4, respectively comprise a westward alignment, which cuts through the dunes just east of Oyster Bay, and a central

alignment, which cuts into the site from the north, through the dunes in the vicinity of the so-called "panhandle".

Although the northern access road is shown in Figure 3.4. Previous iterations of specialist reports in the EIA process (e.g. Day 2010) have indicated that the route would be associated with unmitigably high environmental impacts. As a result, FCG was instructed to remove the detailed assessment of the northern access route from this report, and it is understood that this route is no longer being presented for consideration for authorisation. Comments on the ecological implications of this route are nevertheless provided in the appropriate sections.

It is noted that the Traffic Impact Assessment for the proposed Nuclear1 development refers to four western access alignments in its final (2011) version. FCG was not asked to assess all of these during the course of the present project, since three were eliminated largely on biophysical grounds during previous iterations of the assessment process.

No new access roads to the Bantamsklip and Duynefontein sites would be required.

3.3.2 Staff housing

The EIA application does not include housing developments. It is proposed that housing should be located in the nearest towns. Preference will be given to developing housing in areas already approved for urban development. Alternatively, separate Environmental Impact Assessments will be conducted where necessary to address the impacts associated with off-site housing.

3.4 Site-Specific construction activities

The height of the existing sand dunes at Thyspunt, coupled with the abundance of subsurface water, and the ecological sensitivity of the associated wetlands and terrestrial environment, have led to the formulation by the Eskom engineers of a modified approach to construction of the NPS at this site. To a lesser degree, construction of a NPS at Duynefontein would also be associated with complexities, revolving around construction in the vicinity of a mobile dune system, which is also associated with abundant ground water. Specific approaches to construction at these sites are outlined below – unless specified otherwise, it is assumed that these measures would be applicable to both sites.

3.4.1 Construction of the Nuclear Reactor and Turbine Building at Thyspunt

Construction of the nuclear reactor and turbine buildings at Thyspunt would involve initial excavation into the high vegetated dune, west of the Langefonteinvlei, and stabilisation of the toe of the steep dune edge thus created. Figure 3.5 indicates the proposed approach to stabilisation of the sand dune and to management of groundwater / stormwater flow past the site. A rock fill berm would be used to stabilise the sand, and fitted on its upstream side with a stormwater drain, which allows seepage water and surface runoff from upstream to bypass the built structures.

Construction at Duynefontein would also potentially require excavation into the dune system. A similar approach to sand stabilisation and management of groundwater flows is assumed.

3.4.2 Linkage of transmission lines from the NPS to the proposed HV yard – Thyspunt Site

The proposed location of the Thyspunt HV yard is approximately 3 km from the NPS site, and separated from the site by the mobile dunes.

A portion of the distance to be crossed by the transmission lines is intersected by the mobile high sand dune of the Oyster Bay dunefield, which is some 800 m wide in this area. The following approaches to crossing the dunes, outlined at the specialist integration meeting of November 2009, have been proposed:

- Crossing of the dune using conventional 400 kV transmission towers. The maximum span for standard 400 kV transmission towers is limited to 400 m. This implies that one row of towers will be located approximately in the centre of the moving sand dune. These towers would typically be 30 - 40 m high, although it is noted that the final design has not been completed and these figures might change. Four lines would be needed.
- Crossing of the dunefield using dual circuit 400 kV transmission lines. The maximum span of these is limited to 300 m. This implies that two rows of towers would be located in the mobile dunefield. These towers are typically 50 m high. Two lines would be needed.
- The use of specially designed transmission structures to span the 800 m (600 m width of sand plus 100 m at each edge of the sand) dune field. This option is however considered unlikely to be viable, owing to the strong winds at the site (comment by Eskom technical team made during EIA specialist integration meeting of November 2009).

The total corridor width required for both the single 132 kV distribution line described in Section 3.2.9 and the conventional transmission lines would be 225 m, comprising 50 m for the 132 kV distribution line and 175 m for the four 400 kV transmission lines. The lines would run in parallel.

The total corridor width would be 145 m, if dual circuit transmission lines were used, with the corridor comprising 50 m for the 132 kV distribution line and 95 m for the two 400kV transmission lines. The lines would run in parallel.

It has been confirmed by the Eskom technical team that access roads could run under the transmission lines.

Although Figure 3.3 indicates the option of passage of transmission lines by means of a tunnel beneath the dune, thus was removed from the assessment as it is not viable.

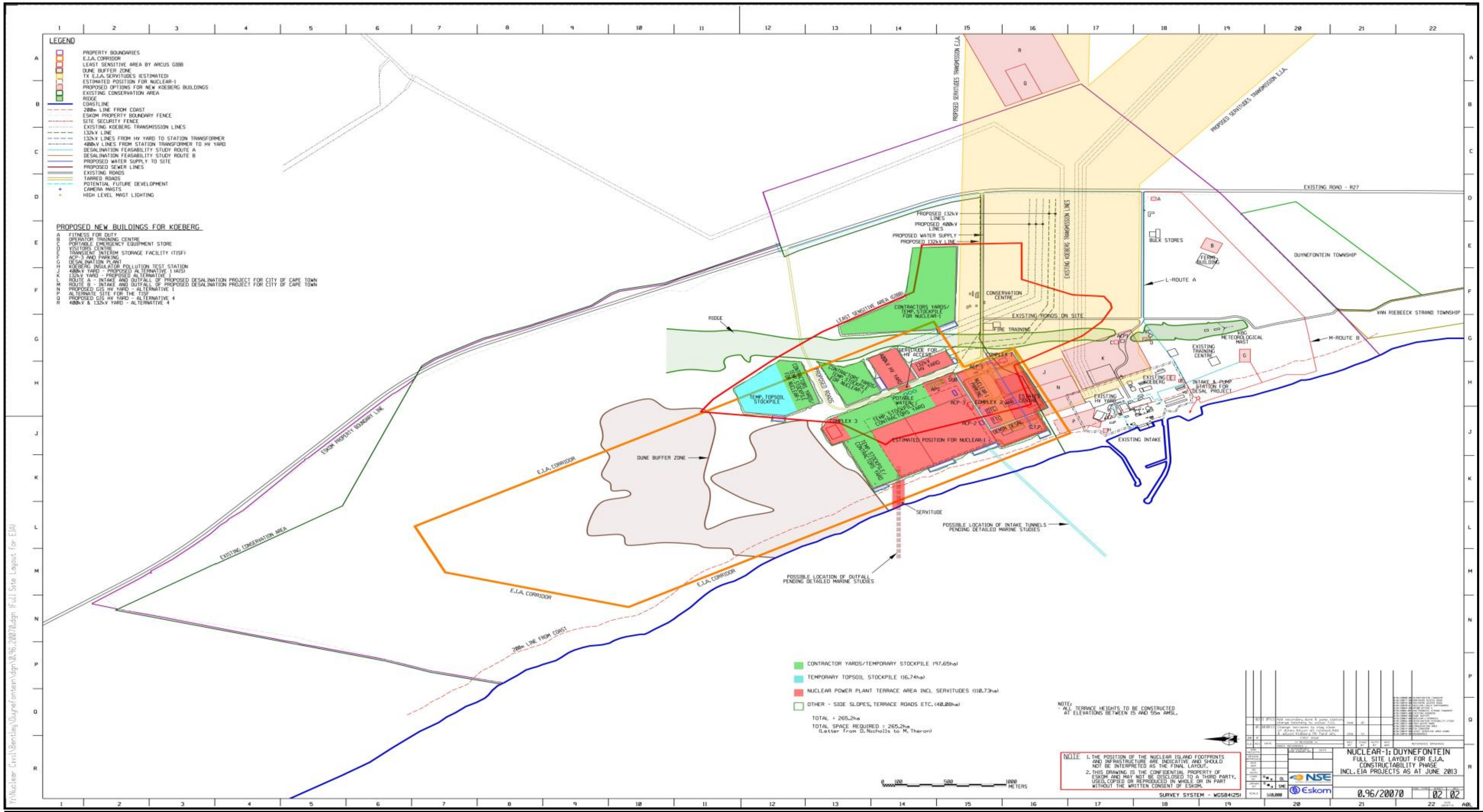


Figure 3.1 **Duynefontein site, showing the areas proposed for the location of different components of the NPS and its ancillary structures, as well as conceptual footprints for the terrace of a 4000 MW plant, a topsoil stockpile and a spoil stockpile. Figure courtesy Eskom.**

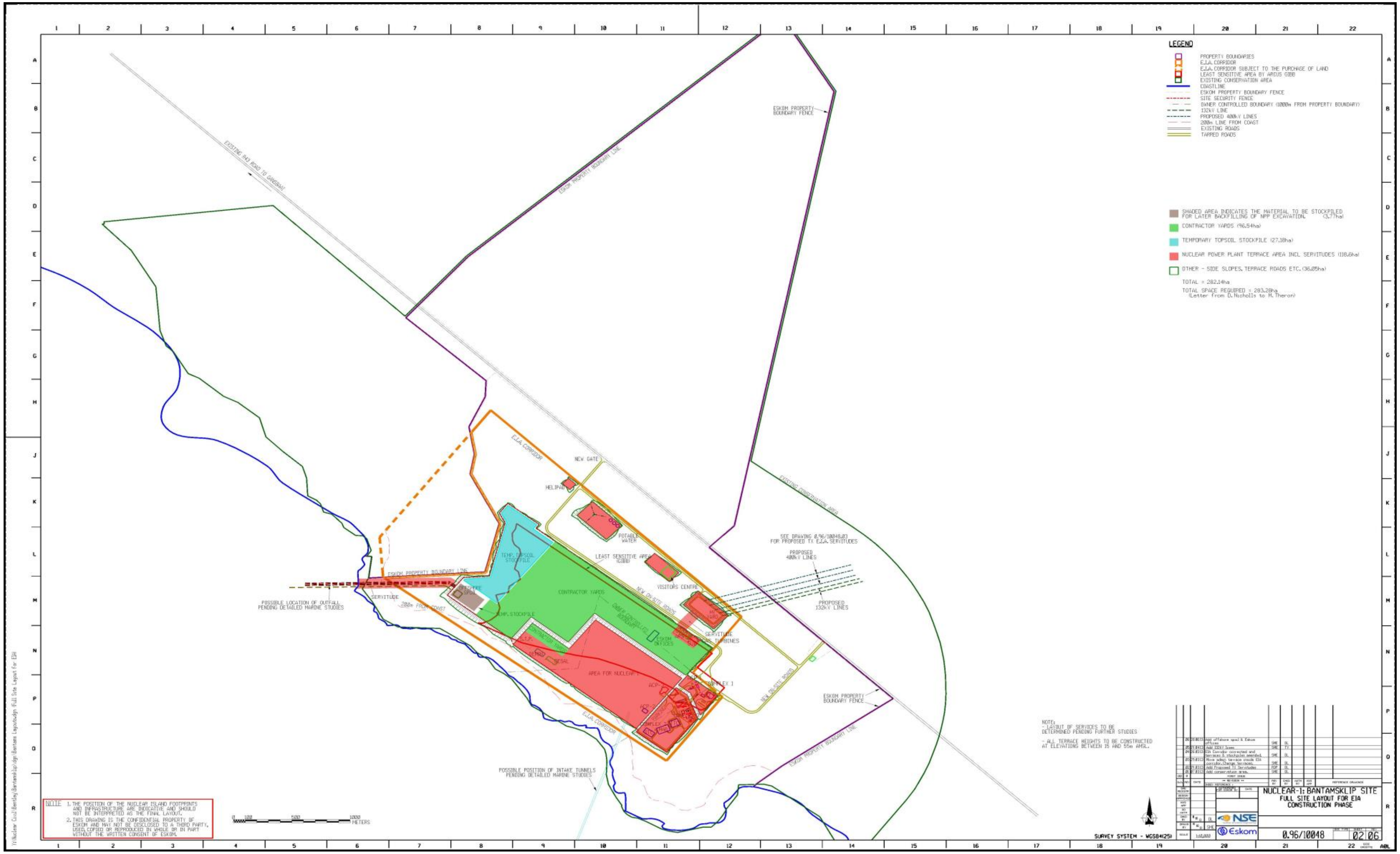


Figure 3.2 **Bantamsklip site, showing the areas proposed for the location of different components of the NPS and its ancillary structures, as well as conceptual footprints for the terrace of a 4000 MW plant, a topsoil stockpile and a spoil stockpile. Figure courtesy Eskom.**

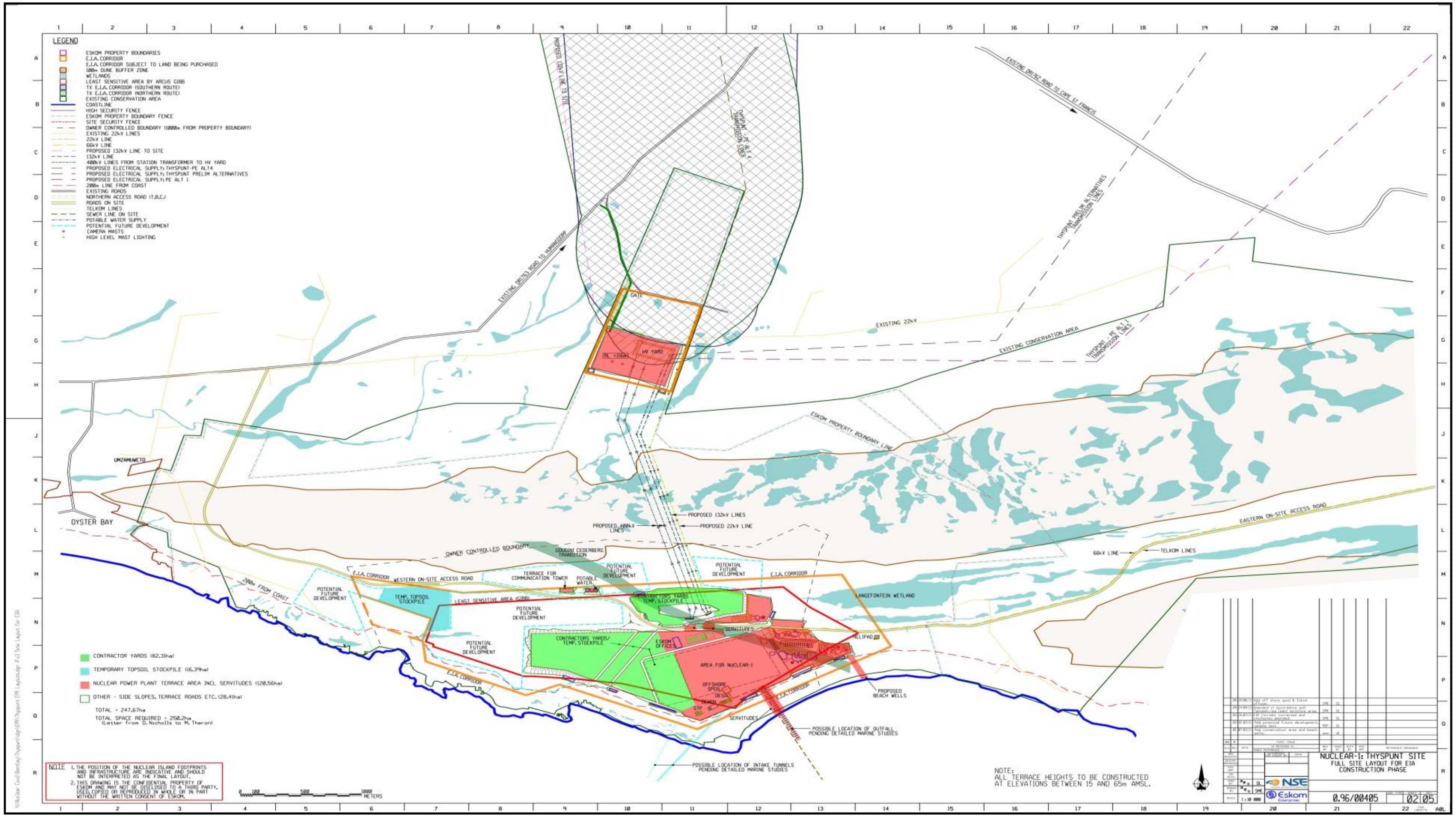


Figure 3.3 **Thyspunt site, showing the areas proposed for the location of different components of the NPS and its ancillary structures, as well as conceptual footprints for the terrace of a 4000 MW plant, a topsoil stockpile and a spoil stockpile. Figure courtesy Eskom.**

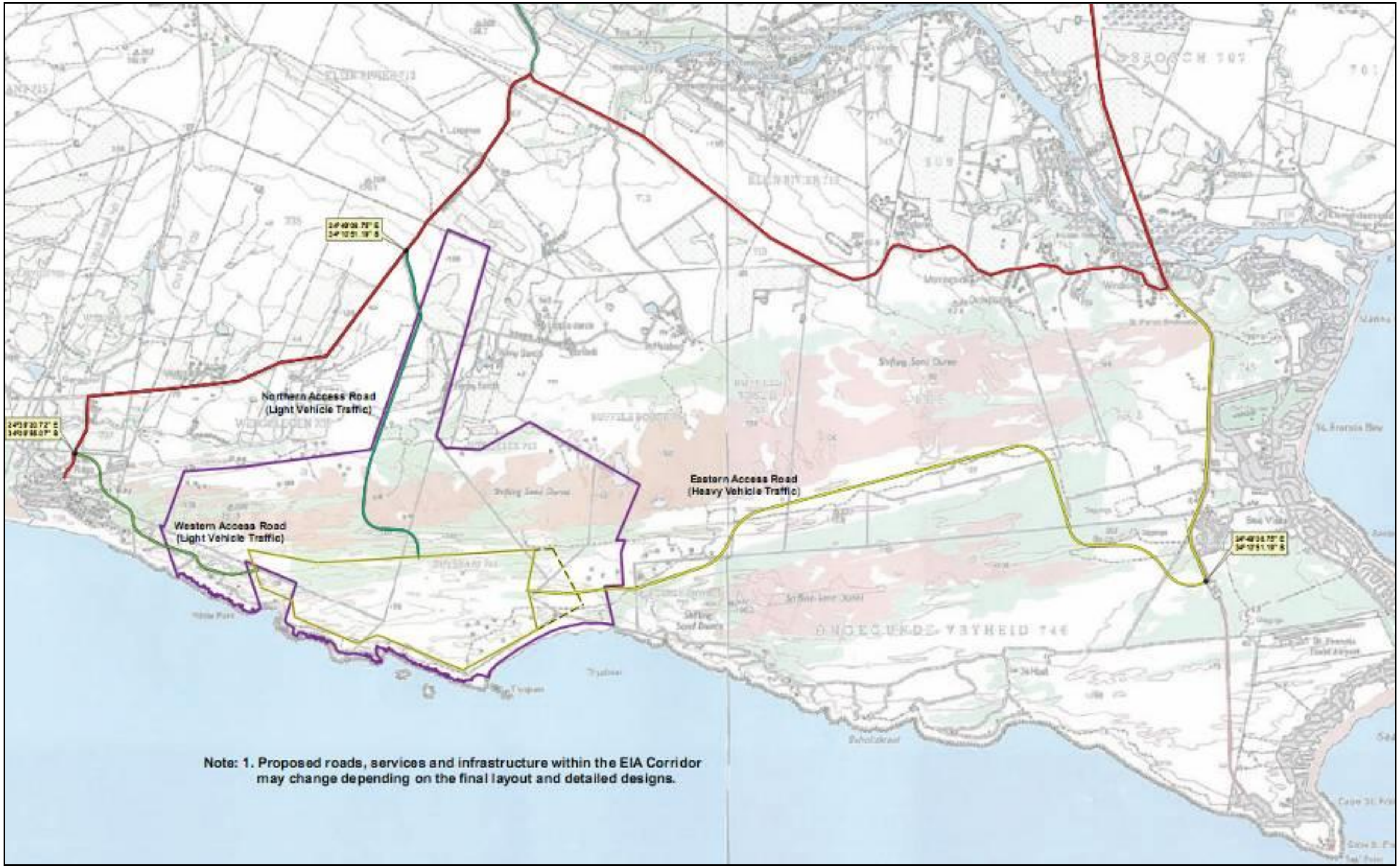


Figure 3.4 Conceptual routing of different site access road alternatives (eastern, northern and western routes) leading to the Thyspunt site. Figure provided by Arcus Gibb. February 2011.

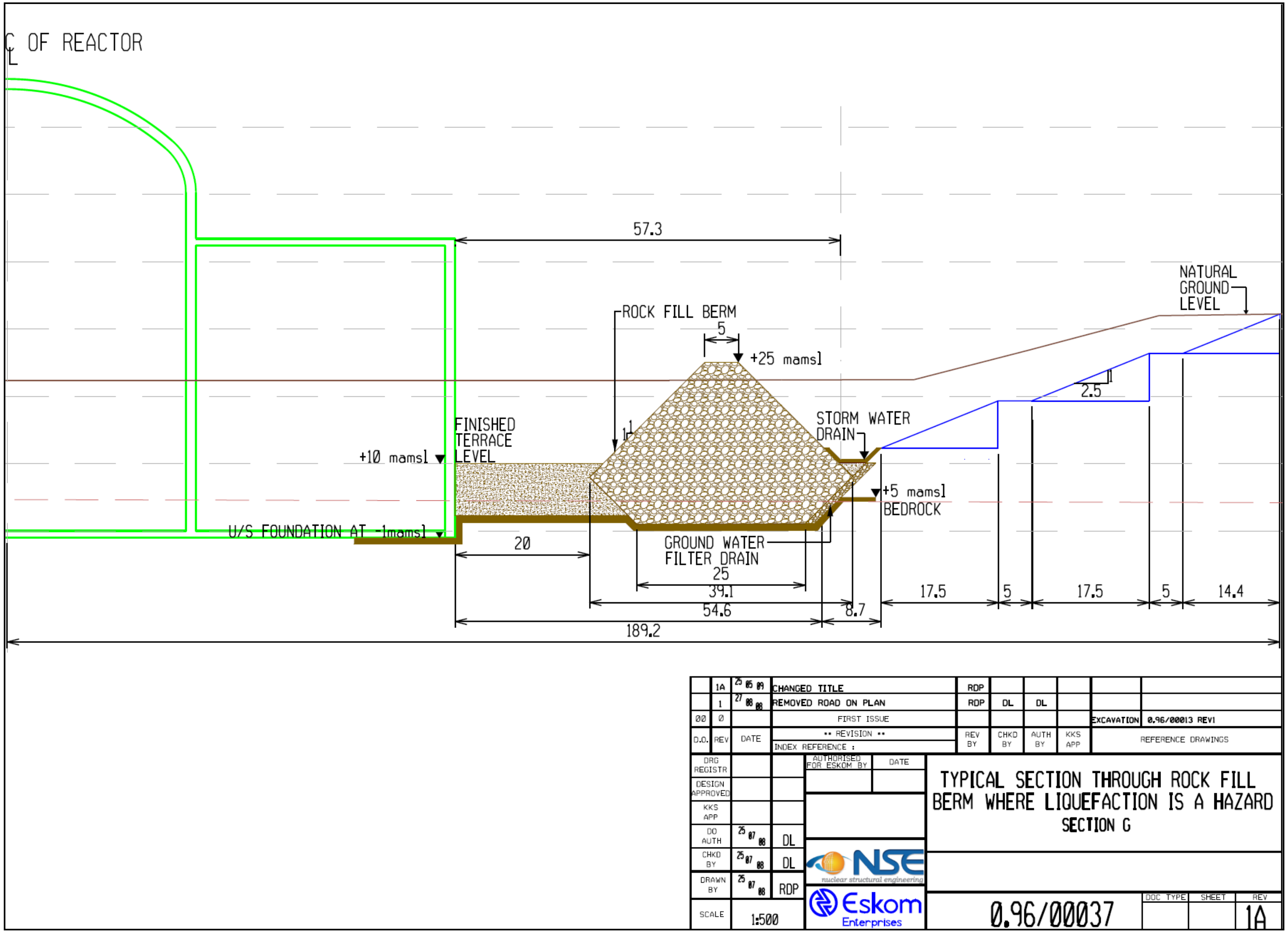


Figure 3.5 **Proposed approach to stabilisation of potential liquefaction areas at the Thyspunt site, showing stormwater drain. Figure courtesy Eskom. Conceptual diagram only – may change in final design.**

4 IMPACT IDENTIFICATION

4.1 Approach to identification of sources of impacts to wetland systems

The implications of development of a single 4000 MW NPS at each of the three proposed sites are explored in this section, in terms of construction and operational phase impacts. Details as to the actual footprint of a future NPS, as well as for the site layout were not yet available at the time of compiling this report. Instead, specialists were initially provided with plans showing broad development envelopes and conceptual ideas of the size of key structures to be arranged within each envelope. Based on these figures, previous versions of this report had to assume a "worst case" scenario in terms of the layout of different components of the development. That is, that the area selected for development of the NPS and other structures within the development envelope was assumed to be that in which the development would have the greatest impact to wetland ecosystems. However, independent reviewers of the EIA criticised such an approach, on the basis that the significance of many impacts, without implementation of mitigation measures, was unreasonably skewed, and higher than it would be in practice. As a result of this interaction, Arcus Gibb requested FCG to revise the EIA assessment, based on an alternative approach. In terms of the revised approach, site sensitivity maps, compiled during specialist integration workshops in 2009, were used to define a reduced envelope within the overall EIA corridor at each site. The site sensitivity maps comprise a composite of all areas identified by biophysical and other EIA specialists as of high ecological importance and sensitivity, as defined in Section 1.4.6. These maps are shown in Figures 4.1A, 4.2A and 4.6A, where they are positioned adjacent to Figures 4.1B, 4.2B and 4.6B showing the recommended development site, derived from an overlay of the composite sensitivity areas over the proposed EIA corridors already presented in Section 3.

The mitigation measures, outlined in Section 5, focus on positioning of the various kinds of infrastructure and buildings associated with the NPS development, such that they would entail the least impact to wetland systems or, alternatively, specifying "no go" areas, which must be avoided if the development is to avoid impacts to freshwater ecosystems. It should be noted that in some instances, the iterative process engaged in between the wetland specialist and the project design team has resulted in early mitigation recommendations already being incorporated into the project design.

The main components that would be included in the EIA envelope shown in each of the proposed site development concepts (Figures 3.1 - 3.3) are likely to comprise:

- The nuclear terrace – within the terrace, the Nuclear Island would need to be set back from the coast by a distance of 200m, to reduce the corrosive effects of the marine environment on the proposed power plant (Eskom 2008c);
- Administrative buildings;
- A visitors' centre;
- Internal access roads;
- A desalination plant;
- A sewage treatment works; and
- Infrastructure such as internal cables, pylons, water pipes.

The site-specific details of these have been outlined in more detail in Section 3.

In addition to the above structures / infrastructure to be accommodated in the EIA envelope, a temporary topsoil stockpile would need to be accommodated somewhere on site during the construction phase, as would a spoil stockpile. The estimated areas that would be occupied by these materials are shown in Figures 3.1 to 3.3. The stockpiles are likely to be on site for an "extended period" during construction, with the construction period expected to span six years (email correspondence from Karin Neethling, Arcus GIBB, to EIA specialists: 7 October 2009).

Although each of the proposed alternative sites includes areas of wetland habitat that have been assessed in this report as of high to very high ecological importance, the implications of development of a NPS for these wetlands differ dramatically, depending on the location of each NPS footprint in relation to freshwater systems and the surface or groundwater linkages they depend on. As such, this report has assessed the implications for wetlands of a NPS development for each site individually. Some repetition is unavoidable in such an approach.

Detailed ratings of impact significance are provided in Tables 5.1, 5.3 and 5.5, in Section 5, along with recommendations for impact mitigation.

4.2 Impacts associated with development of a nuclear power station at Duynefontein

4.2.1 Overview

Figures 4.1A and B show the layout of the proposed NPS, in the context of wetlands on the Duynefontein site. The EIA corridor in which the proposed NPS (phase 1) would be located extends from just north of the existing Koeberg NPS, beyond the mobile dunes, to just north of the infiltration ponds (artificial wetlands P3a-d). However, the "recommended development area" (or area of least impact) is located in the southern portion of the EIA corridor, extending across the mobile dunes to a position just short of the duneslack wetland Sw7, described in Section 2.1.2 (Figure 4.1B). The administration, training, emergency control and support centres would all need to be positioned within this area, as well as space for parking and construction-associated laydown, as would the proposed desalination plant, the polluted stormwater waste water pond and the proposed WWTW.

4.2.2 Impacts associated with the construction phase

i Loss or degradation of wetlands

This impact would result from the following activities, described and assessed separately below, in order to allow for clearer identification of key impacts and their mitigation:

A Changes in hydroperiod resulting from dewatering

Assuming that the NPS site is located south of the mobile dunes, within the "preferred development area", construction-phase dewatering during excavation to construct the nuclear island and the turbine hall is highly unlikely, in terms of the revised geohydrological model (Visser *et al*. 2011), to have any impact on the expanse of duneslack wetlands to the south of the Koeberg NPS (i.e. wetlands in and around Sw1 and Sw2). The results of the updated numerical modelling of surface – groundwater interactions on the site under conditions of construction-associated draw-down (Visser *et* al. 2011) indicate that the dewatering zone may extend to a maximum of 1.3 km (1 m drawdown) when dewatering the entire NPS footprint, thus affecting the wetlands shown in Figure 4.1C. However, these wetlands comprise the artificial wetlands P2c and P2d, which probably originally resulted from excavation of borrow pits during construction of the R27.

The wetlands located in the northern sections of the site (including Sw7) should not be affected by the dewatering.

The coastal wetlands in the south-western portion of the site have been conservatively assessed as having low (rather than no) sensitivity to potential drawdown. Provided that drawdown is short-term (i.e. over one or two years), and provided that its indirect impacts on wetlands (e.g. increased invasion of drier areas by alien vegetation) are controlled, these wetlands are likely to be relatively resilient to drawdown. Aquatic biodiversity should recover quickly once water levels are restored. This assessment is based on the fact that the wetlands are naturally prone to periodic desiccation, and indeed support fauna that occur in these habitats only because there is prolonged annual desiccation. Wetland vegetation would be likely to recover from drawdown desiccation over a slightly longer period (up to five years).

<u>This impact has been assessed as of low to medium significance (Table 5.1).</u>

B Seawater contamination following dewatering

Contamination of wetlands with seawater would result in extensive die-back of existing fresh-to-brackish associated wetland vegetation, loss of invertebrate fauna with brackish to fresh tolerance ranges and, if the impact persisted, the establishment of different, probably less diverse wetland communities, with higher salinity tolerances.

Visser *et al.* (2011) re-modelled the impact of dewatering of a conceptual NPS site on seawater intrusion, and found that seawater intrusion could be expected to occur within a radius of 600 m along the coastline in the vicinity of a proposed NPS footprint as a result of dewatering, which might lead to a slight increase in salinity in wetlands closest to the footprint. The only wetlands that fall into this category would be the artificial wetlands P2c-d, and potentially the degraded *Ficinia nodosa* wetland area north of the important seasonal wetlands represented by Sw1 and Sw2 (Visser *et al.* 2011).

<u>This impact has been assessed as of low to medium significance to wetland ecosystems, but it is noted that the probability of the impact occurring is considered extremely low.</u>

C Construction of internal access roads

Figure 4.1B indicates the alignment of two new access roads between the proposed NPS site and the R27. These roads would be aligned along existing internal dirt roads on the site, which would be upgraded to allow their use by heavy construction vehicles (Eskom 2008b). The most southerly of the two proposed roads, as shown in the figure, runs in the proximity of seasonal wetland Sw5. Construction of the two roads could result in direct disturbance to wetland Sw5 as a result of construction-related disturbance. The significance of impact is likely to be negative but low.

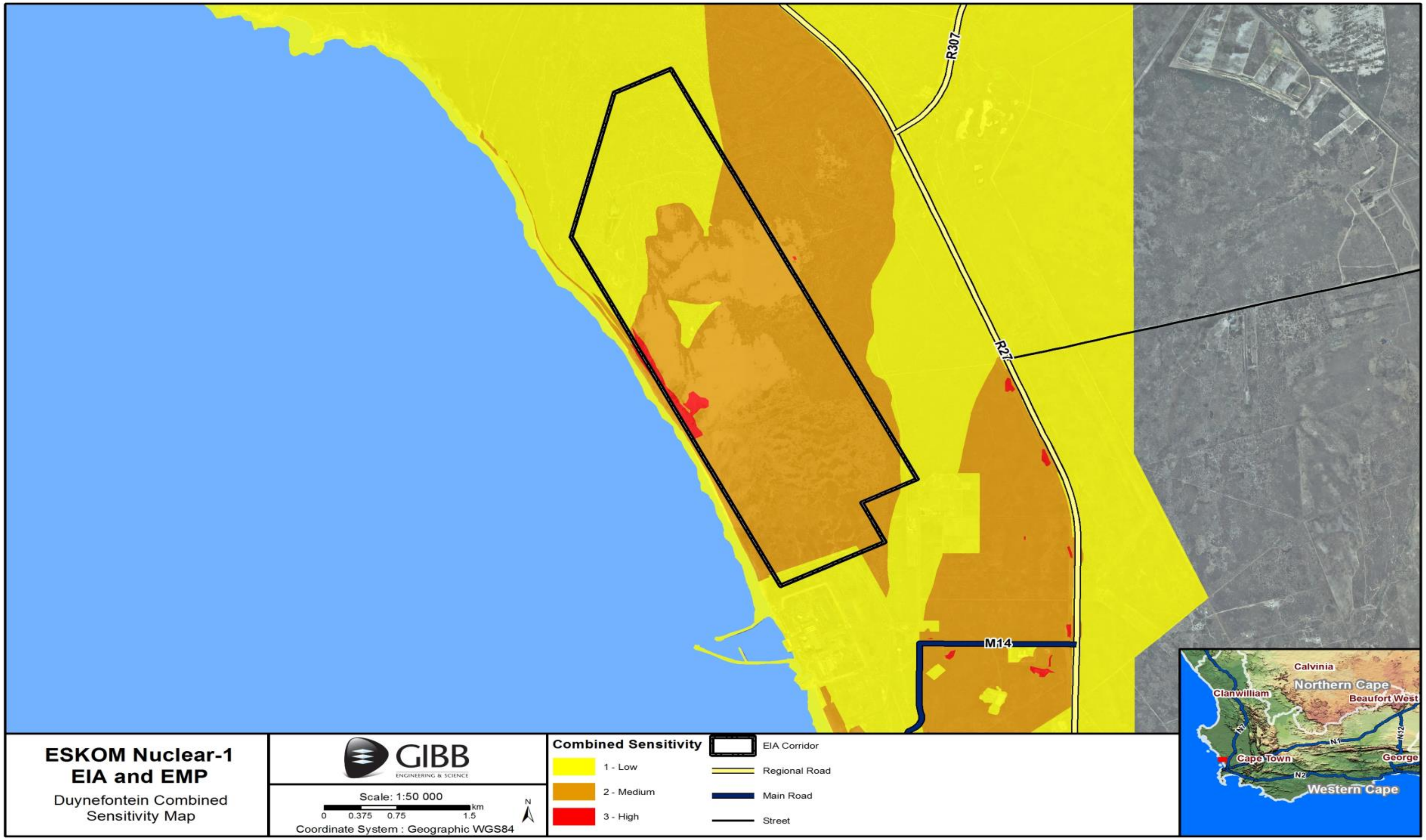


Figure 4.1A **Determination of a least sensitive development area at Duynefontein, based on an overlay of mapped sensitivity areas for different specialist disciplines in the EIA process. Note that wetlands were not a major driver in the determination of a "recommended [development] site" at Duynefontein. Figure courtesy of GIBB.**

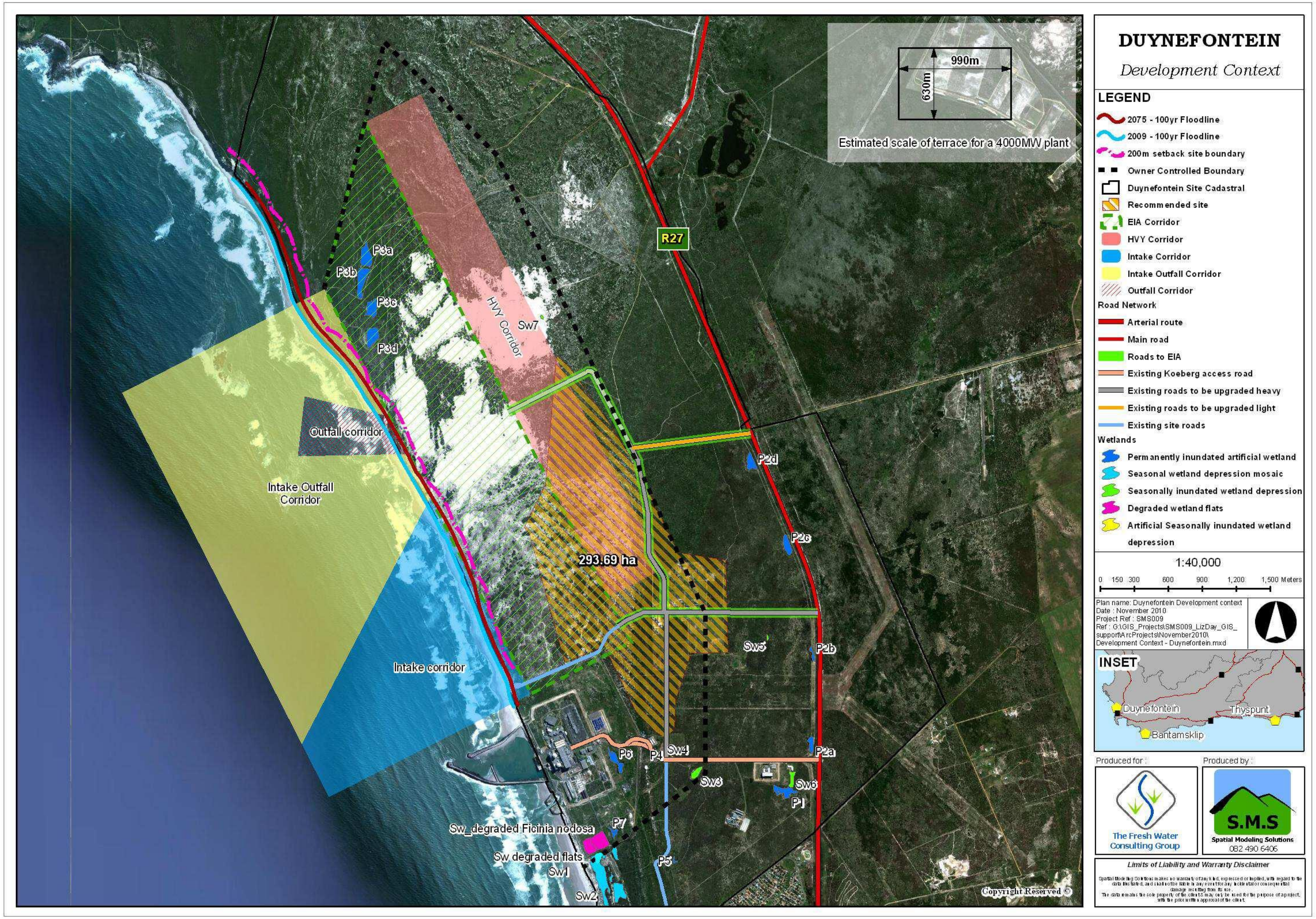


Figure 4.1B **Proposed corridors for the location of different components of an NPS at Duynefontein, showing development corridors and proposed infrastructure in the context of wetlands mapped at the site. Block on right hand corner indicates relative size of conceptual NPS footprint- footprint dimensions courtesy Eskom. "Recommended site" (or least sensitive development area) derived as per Figure 4.1A.**

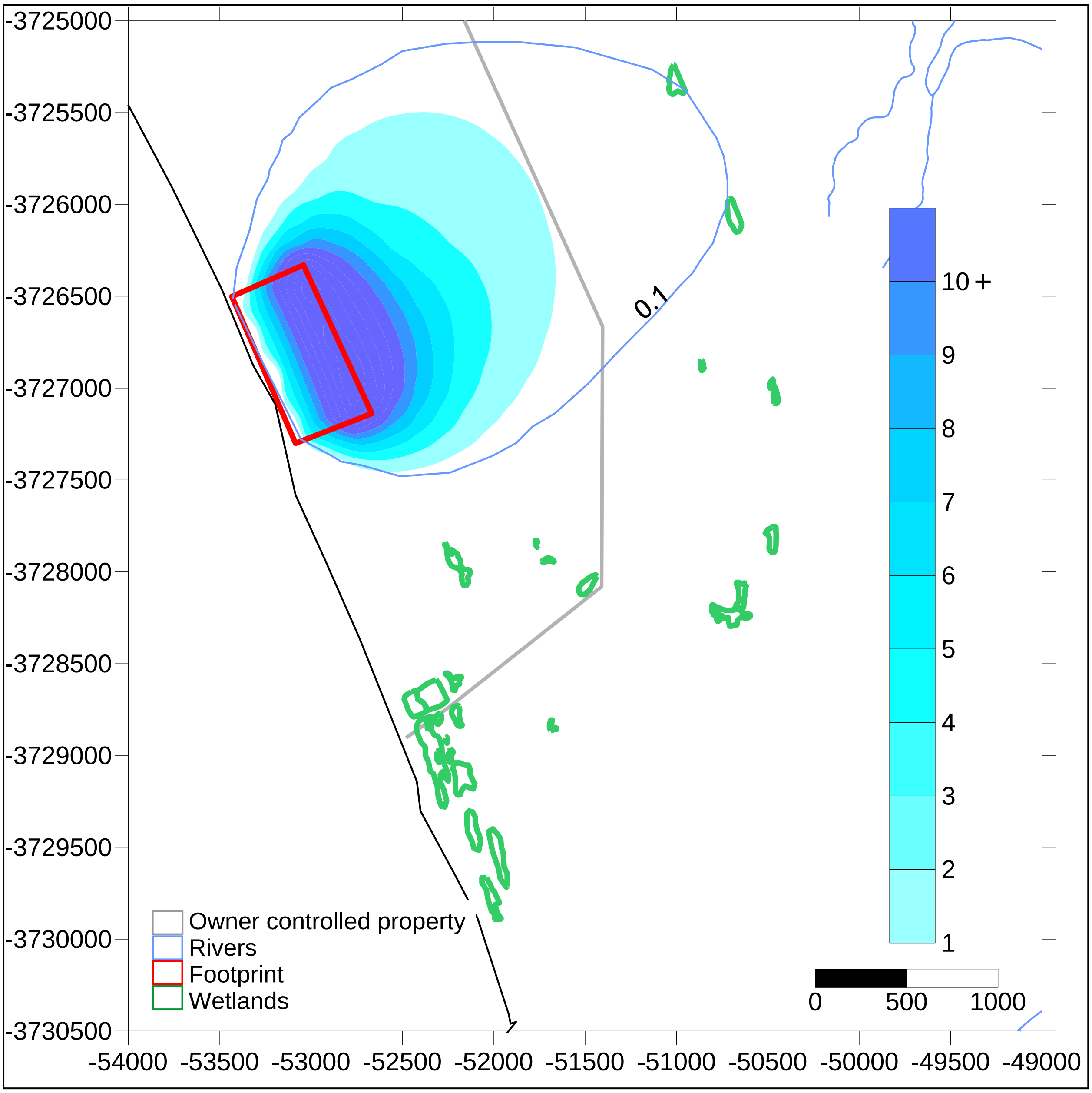


Figure 4.1C Modelled sensitivity of wetlands on the Duynefontein site to construction-associated groundwater drawdown. Model based on drawdown of the entire NPS footprint, and thus an exaggeration of extent of impact. Figure after Visser et al. (2011).

4.2.3 Impacts associated with the operational phase

Degradation and fragmentation of wetlands as a result of operational phase use of internal access roads

Construction of new access roads to the proposed NPS site in the vicinity of SW5 would result in sustained degradation of this habitat as a result of:

- Runoff of stormwater from the road into the wetland – this impact is considered of minor significance;
- Disturbance to a presently secluded habitat as a result of nearby traffic; and
- Permanent separation of the wetland from adjacent natural areas to the north, increasing internal habitat fragmentation within the site.

These impacts have been assessed as of (very) low negative significance.

4.2.4 Cumulative impacts of development of a single NPS at Duynefontein

Without the implementation of mitigation measures, but assuming that the development is located within the "preferred" development area (4.1B), the implications of development of a single NPS at Duynefontein have been assessed as of low negative significance from a wetland perspective.

4.2.5 Implications of climate change for wetlands on the Duynefontein site

The data / descriptions of climate change variables provided by Prestedge *et al.* (2009) and PRDW (2009a) have been used to guide the assessment of climate change implications for wetlands at this site. These sources suggest:

- An increase in sea level of 0.8m over the next 100 years, as modelled by IPCC (2008);
- An increase in wind speeds, wave height and storm surge (PRDW 2009a);
- An average reduction in streamflow of around 0.32% per annum New (2002) (cited in Dallas and Rivers-Moore 2008);
- An increase in groundwater levels of ~0.55 m across the site, associated with a 0.8m rise in sea level (SRK 2009); and
- A landward expansion of the projected 1:100 year floodline between the present (2009 line) and 2075 – a time period that would span a 60 year operational phase of a single NPS at the Duynefontein site, assuming a construction date of 2015 (unreferenced GIS metadata for 1:100 year floodline data). The locations of the two floodlines are shown in Figure 4.1B.

<u>Wetland perspective:</u>

- 0.5m rise in groundwater level could result in an upward expansion of the seasonal duneslack wetlands south of the Koeberg NPS as well as some increase in the likely extent of duneslack wetlands such as Sw7, which are presently rare on the site. Increased groundwater levels across the site mean that duneslack areas in the dunes that presently are just too dry to support wetland vegetation (e.g. Mw1) may in the future give rise to wetter conditions and the formation of seasonally inundated to saturated wetlands. The biodiversity importance of such systems would depend in part on the persistence of similar habitat types in the area, to serve as nodes for colonisation of new areas.

  One of the more problematic effects of increased groundwater levels may be a loss of biodiversity associated with an extended hydroperiod in areas that naturally dry out entirely during summer. Day *et al*. (2009) noted that hydroperiod appeared to be one of the key factors determining the presence or absence of key micro-crustacean taxa in seasonal wetlands. This study, using soil moisture data from Bird (2009), assessed aquatic invertebrate fauna from over 30 wetland depressions in the Cape Town Municipal Area (CMA), including those in the seasonally inundated wetlands south of the Koeberg NPS, and correlated wetlands that dried completely during summer with higher species number and the presence of branchiopod taxa. An extended hydroperiod in the southern wetlands, which currently dry out completely during summer (Day et al. 2009), may result in biodiversity loss. The degree to which new seasonally inundated / seasonally dry wetlands would be created elsewhere as a result of raised groundwater levels is uncertain.

- The 0.8m rise in sea level that promotes the rise in groundwater level discussed above would be accompanied by an increase in salinity in areas close to the shore – this means that coastal wetlands very close to the shore (e.g. just east of the low beach dune in the wetlands south of the Koeberg NPS) would be more likely to become saline, and potentially support saltmarsh habitat rather than the brackish wetland biota they currently support. This may have biodiversity implications, resulting in the loss of taxa, particularly zooplankton, with limited distribution ranges (see Section 2.1). If the wetlands became completely seawater-fed, a large-scale loss in biodiversity would be likely;
- Increased salinities along the coastal wetlands might be exacerbated if higher waves and surges increased the frequency at which sea waves breach the low dunes during storms; and
- Increased temperatures and decreased rainfall associated with climate change could decrease the resilience of wetlands to anthropo-morphological stresses, such as pollution, physical disturbance; channelisation and water abstraction.

The above impacts are likely to affect the most sensitive seasonally inundated duneslack depressional wetlands south of the Koeberg NPS. They are not likely to affect the other wetlands on site, with the exception of wetlands within the mobile dunes, which may expand across low-lying points in the dunes.

4.3 Impacts associated with development of a nuclear power station at Bantamsklip

4.3.1 Overview

Figure 4.2B shows the layout of the proposed NPS, in the context of wetlands on the Duynefontein site. Both the original EIA development "envelope" and the "recommended development area" (i.e. the area of least overall sensitivity) are indicated in the figure. The latter is located in the south eastern portion of the EIA corridor, and lies well south of the R43. In this regard, it is noted that a fundamental assumption underlying the assessment of the proposed NPS at Bantamsklip is that none of the activities associated with the construction or operational phases of the NPS would take place north of the R43. This assumption has been verified by Eskom (1st specialist integration meeting of 2008).

4.3.2 Impacts associated with the construction phase – Phase 1

A Loss or degradation of wetlands as a result of dewatering

Figure 4.3 indicates the implications of various dewatering scenarios for wetlands on and associated with the Bantamsklip site, based on the outcomes of re-modelled draw-down scenarios, presented by Visser *et al*. (2011).

The results shown in Figure 4.3 pertain to a single NPS installation, and assume that one third of the proposed NPS site would be dewatered. The model indicates a limited zone of depression, that is unlikely to result in any impacts to the Groot Hagelkraal River or to any other identified wetland system, as a result of dewatering (Visser *et al*. 2011). The addition of an impermeable to semi-permeable membrane to the dewatering design would further reduce the extent of drawdown. It is noted that the volume of draw-down modelled by SRK (2009) for Bantamsklip is cited as orders of magnitude lower than that for either of the other two sites, with daily dewatering volumes of only 34 m^3, compared to 6500 m^3 / day at Duynefontein and 3400 m^3 /day at Thyspunt for the same scenario.

The impact of dewatering on wetland systems has been assessed as of low to medium significance only, with a low probability of impact occurrence.

B Loss or degradation of wetlands as a result of other construction-related impacts on the site south of the R43

Given that all the wetlands identified on the Bantamsklip site lie north of the R43, and that construction activities will be confined to the area south of the R43, no impacts to wetland systems are likely as a result of any activities associated with construction.

Construction phase impacts to the south of the R43 have thus been assessed as being of no significance.

C ***Degradation of wetlands as a result of physical disturbance to wetlands north of the R43 during construction***

Although the proposed NPS site itself lies south of the R43, the area to the north of this road, which includes portions of the ecologically important Groot Hagelkraal wetland system (see Section 2.2), is potentially vulnerable to impacts associated with the increased number of personnel likely to be associated with the site as a whole during construction. Eskom (2008b) notes that site offices will be established "somewhere on the Eskom property" or in a developed area close to Bantamsklip. The use of existing buildings north of the R43 for such purposes may thus be considered. An associated increase in vehicle and human traffic into this area could result in some degradation of wetland systems in the vicinity of existing buildings. Sources of degradation would include increased traffic across road crossings through wetlands and increased pedestrian traffic into the wetlands. Given that infrastructure shown in Figure 3.2 lies to the south of the R43, the likelihood of substantial ingress to areas to the north of this road is considered very low. Construction-phase impacts to the area north of the R43 have thus been assessed as being of low probability, but of low to medium significance, given the importance and sensitivity of the system.

D Impacts of linking transmission lines from the NPS to the proposed HV yard

The HV corridor lies adjacent to the EIA corridor. Neither of these areas is associated with any wetlands, and no impacts to wetland systems would be associated with the transmission lines between these sites.

4.3.3 Impacts associated with the operational phase

A Abstraction of surface or groundwater to supply fresh water to the NPS

Use of water from the Groot Hagelkraal system and associated groundwater has specifically been excluded from the Bantamsklip fresh water supply options (Marshall, 2008), and it is thus assumed that all freshwater requirements for the site would be met by desalinisation.

No impacts to freshwater ecosystems are likely to be associated with the proposed desalinisation of sea water to meet fresh water requirements on the site.

No impacts to wetland / freshwater ecosystems are thus anticipated as a result of servicing fresh water supply requirements on the site.

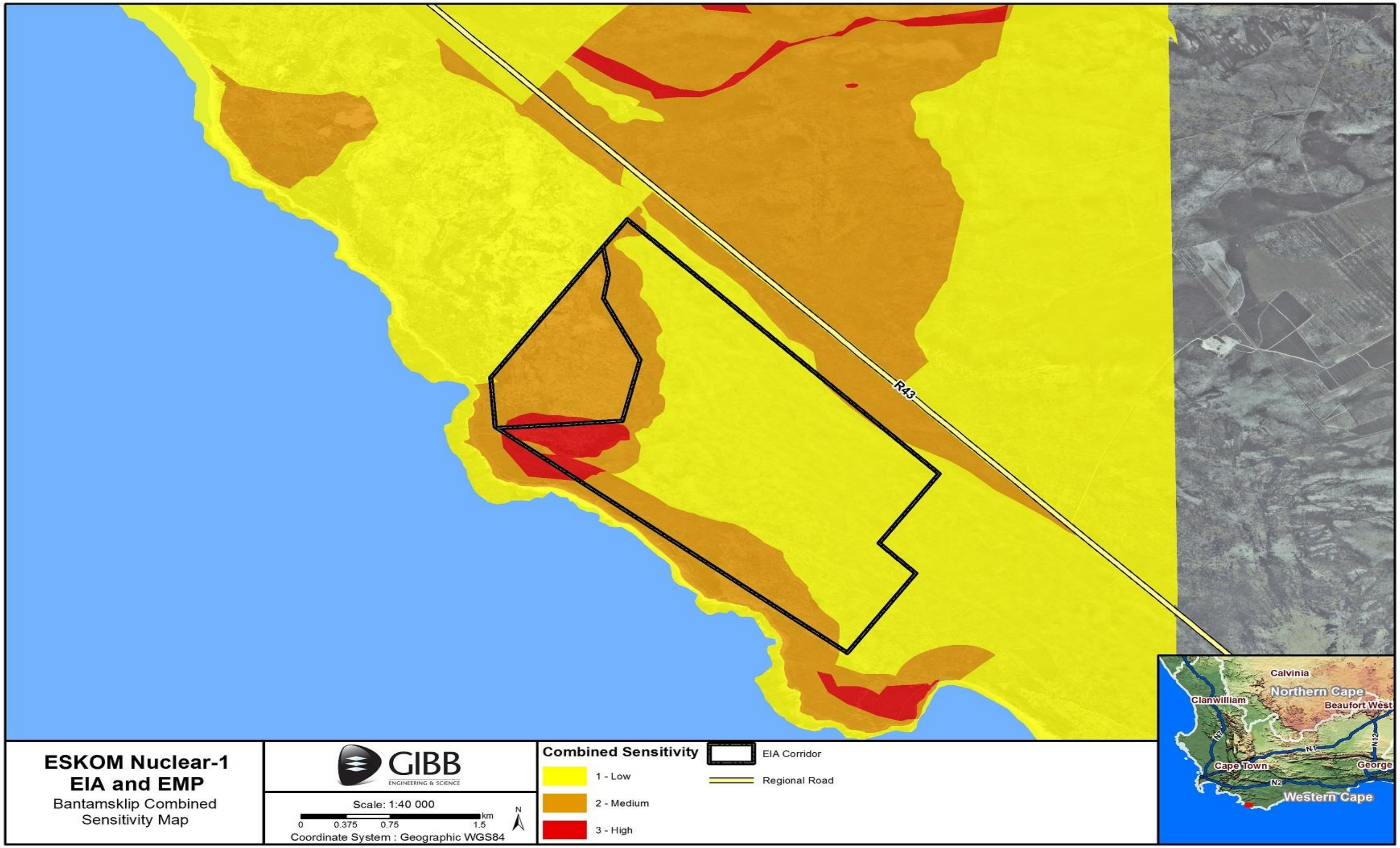


Figure 4.2A Determination of a least sensitive development area at Bantamsklip, based on an overlay of mapped sensitivity areas for different specialist disciplines in the EIA process. Figure courtesy Arcus Gibb.

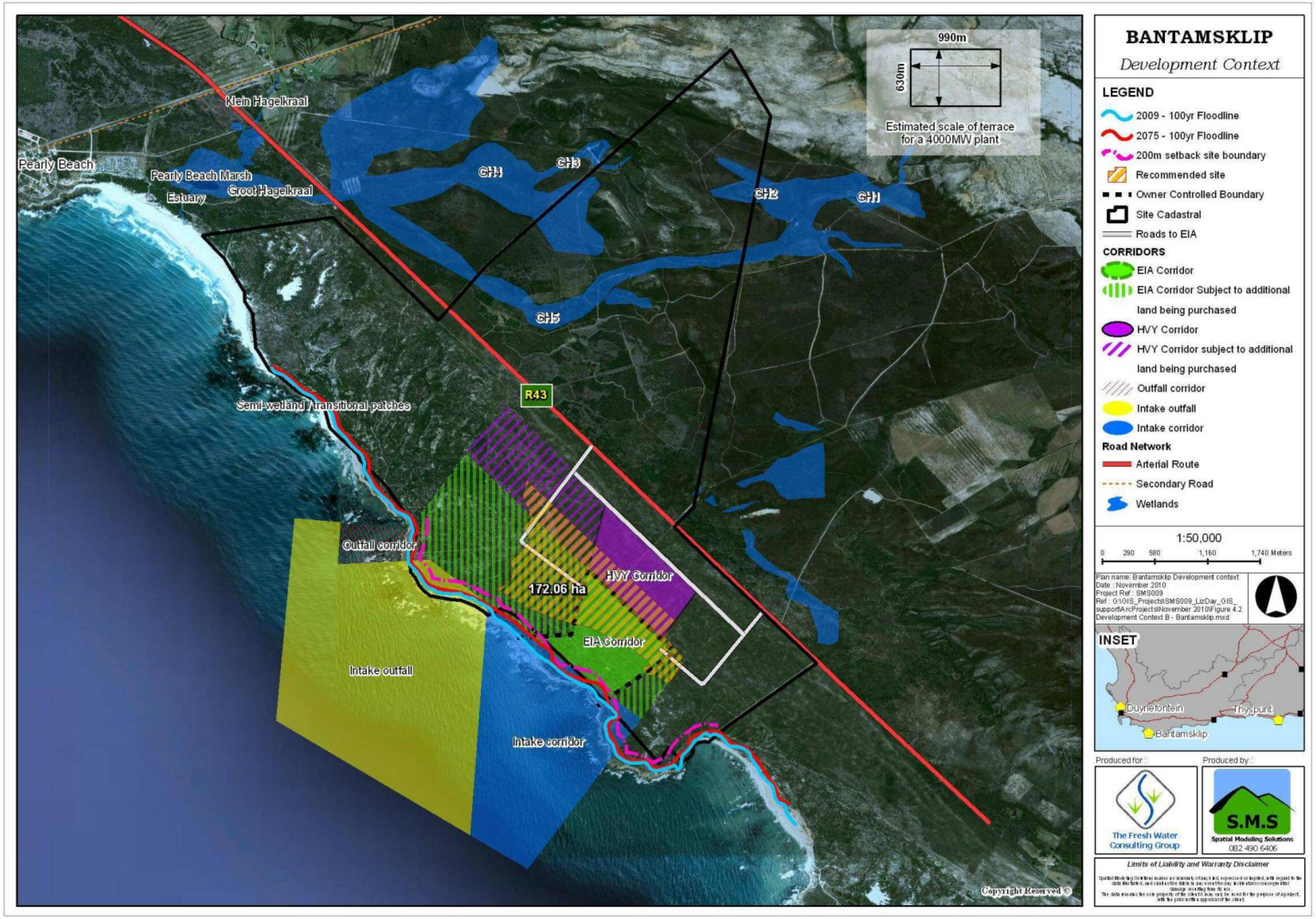


Figure 4.2B **Proposed corridors for the location of different components of an NPS at Bantamsklip, showing development corridors and proposed infrastructure in the context of wetlands mapped at the site. Block on right hand corner indicates relative size of conceptual NPS footprint- footprint dimensions courtesy Eskom. "Recommended site" (or least sensitive development area) derived as per Figure 4.2A.**

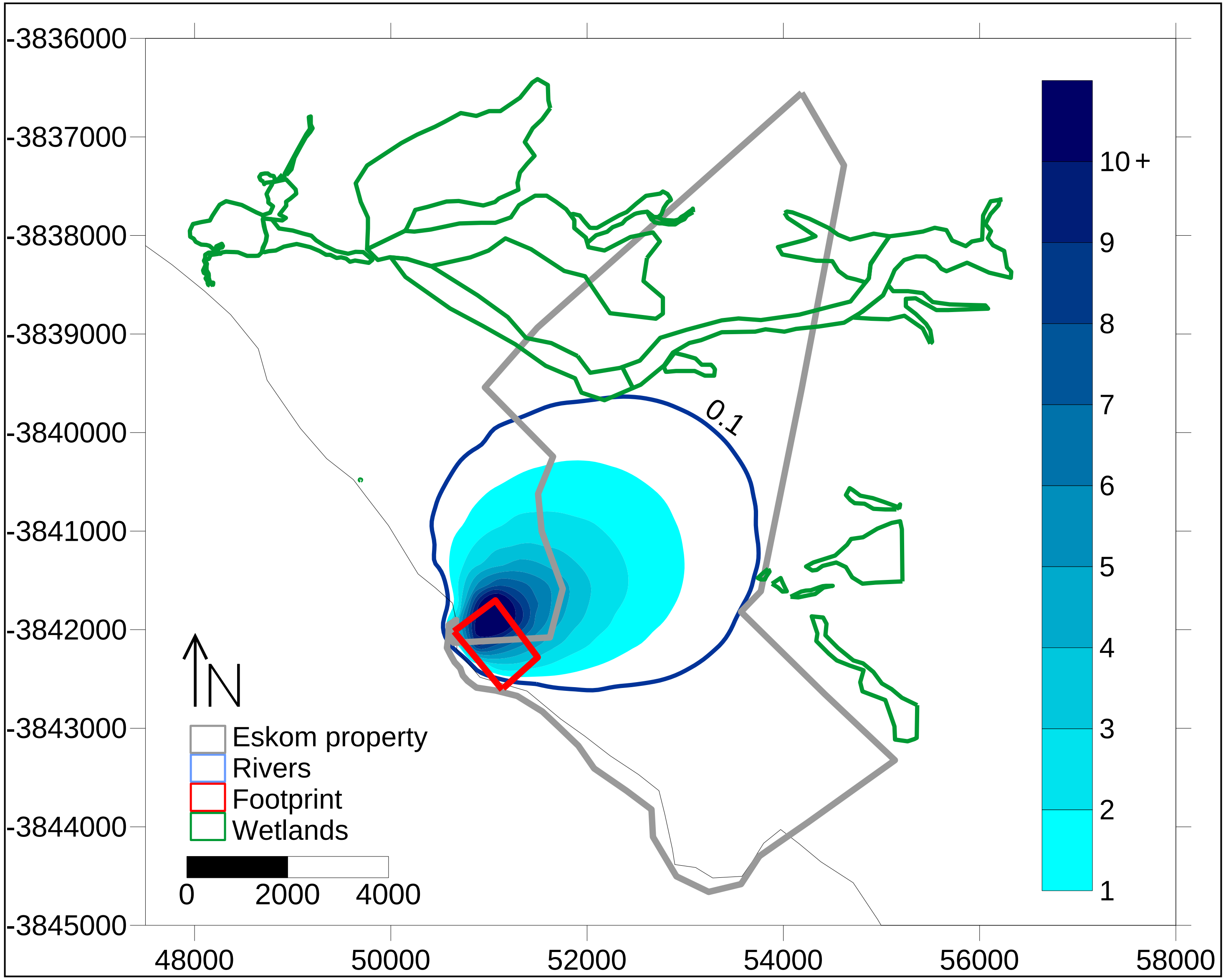


Figure 4.3 **Modelled radius of drawdown at the Bantamsklip site. Figure after Visser *et al* (2011). Drawdown model based on dewatering of an area equivalent to one third of one NPS footprint.**

B Degradation of wetlands associated with the Groot Hagelkraal system through alien encroachment

An important assumprton of this assessment is that, even if existing buildings on the site north of the R43 are used as construction phase offices, the entire site north of the R43 will be excluded from the NPS development during its operational phase. The area will however remain under the control of Eskom. It has not specifically been stated that this area will be managed as a Nature Reserve although it is understood that this is Eskom's intention (Mr G. Greeff, Eskom, pers. comm.).

In the absence of active conservation-oriented management of this site, its degradation is highly probable. Invasion by alien vegetation is likely to expand rapidly, resulting in wetland shrinkage and loss of habitat; nick-points of erosion along the wetland system, already highlighted in Section 2.2 might, without careful management, progress further, leading to ongoing degradation and biodiversity loss through management failure.

These impacts have been assessed together as being of low to medium negative significance. It is acknowledged however that even at present the site is being actively managed by Eskom, and that alien clearing is taking place throughout the Eskom property.

C Increased fragmentation of wetlands up- and downstream of the Groot Hagelkraal system as a result of increased road use along the R43

A substantial increase in traffic is anticipated along the R43 between Gansbaai and the access to the NPS. The Groot Hagelkraal system has already been dissected by the existing road. Nevertheless, low volumes of traffic along the road mean that, particularly at night, movement of wetland associated fauna up and down the river corridor, potentially between the beach and upland wetlands north of the R43, is still possible. As traffic volumes increase along the road, so the number of road kills is likely to increase and the efficacy of links between the sea and the uplands will be decreased.

The impact on the biodiversity function of the Groot Hagelkraal wetlands impact has been rated as of low negative significance.

Comments on the impacts to wetland systems associated with indirect impacts of the proposed NPS development

The development of a NPS at the Bantamsklip site would also involve the influx of a relatively large number of personnel into an area with a presently low population. Correspondence from Eskom (Marshall 2008) has indicated that personnel will be housed in the area "between Gansbaai and Pearly Beach" and that the WWTW at Gansbaai will be upgraded to allow for the increased effluent load.

Although the present EIA specifically excludes an assessment of the impacts of off-site development associated with the proposed NPS development, it is noted that an increase in the local population in the Pearly Beach area could result in negative implications for systems such as the lower reaches of the Groot Hagelkraal River, if these are placed under increasing pressure as a result of higher local populations and their need for infrastructure. Examples of potential impacts include the need for increased sewage treatment capacity in the Pearly Beach area and a mechanism for the disposal of treated effluent, if this area is used for even a proportion of staff housing.

4.3.4 Implications of climate change for wetlands on the Bantamsklip site

The following data / descriptions of climate change variables, taken largely from Prestedge et al. (2009) and PRDW (2009b) have been used to guide the assessment of climate change implications for wetlands at this site:

- An increase in sea level of 0.8m over the next 100 years, as modelled by IPCC (2008);
- An increase in wind speeds (10% increase), wave height (17%) and storm surge (21%) (PRDW 2009b);
- An average reduction in streamflow of around 0.32% per annum New (2002) (cited in Dallas and Rivers-Moore 2008);
- An increase in groundwater levels of up to 0.58m, with increases of up to 0.4m extending across the Eskom property, as shown in Figure 4.4, based on data from SRK (2009);
- A landward expansion of the projected 1:100 year floodline between the present (2009 line) and 2075 – a time period that would span a 60 year operational phase of a single NPS at the Bantamsklip site, assuming a construction date of 2015 (GIS data from Prestedge *et al*. 2009). The locations of the two floodlines are shown in Figure 4.4.

<u>Wetland perspective:</u>

- No direct impacts to wetlands on the Bantamsklip site would be associated with a rise in sea level. However, it is possible that wetlands such as the Pearly Beach coastal marsh might become more saline in time, if exposed to increase storm surges, higher wave height and increased sea levels. The wetlands associated with the Groot Hagelkraal estuary would also be vulnerable to erosion, and substantial change in vegetation zonation, as a result of increased sea level. Plant communities that were not eroded out of the system would be likely to undergo a shift towards dominance by plants characteristic of salt marshes, rather than the present plant community, which is dominated by plants typical of fresh to slightly brackish conditions (e.g. *Juncus kraussii*).
- Increased temperatures and decreased rainfall associated with climate change could decrease the resilience of wetlands to anthropo-morphological stresses, such as pollution, physical disturbance; channelisation and water abstraction.
- Increases in groundwater level in the upper and lower reaches of the Groot Hagelkraal River (Figure 4.4) might result in expansion of the existing hillslope seeps and valley bottom wetlands associated with this site. However, such expansion might be offset by potential reduced streamflow as a result of decreased precipitation and higher temperatures, as described by Dallas and Rivers-Moore 2008).

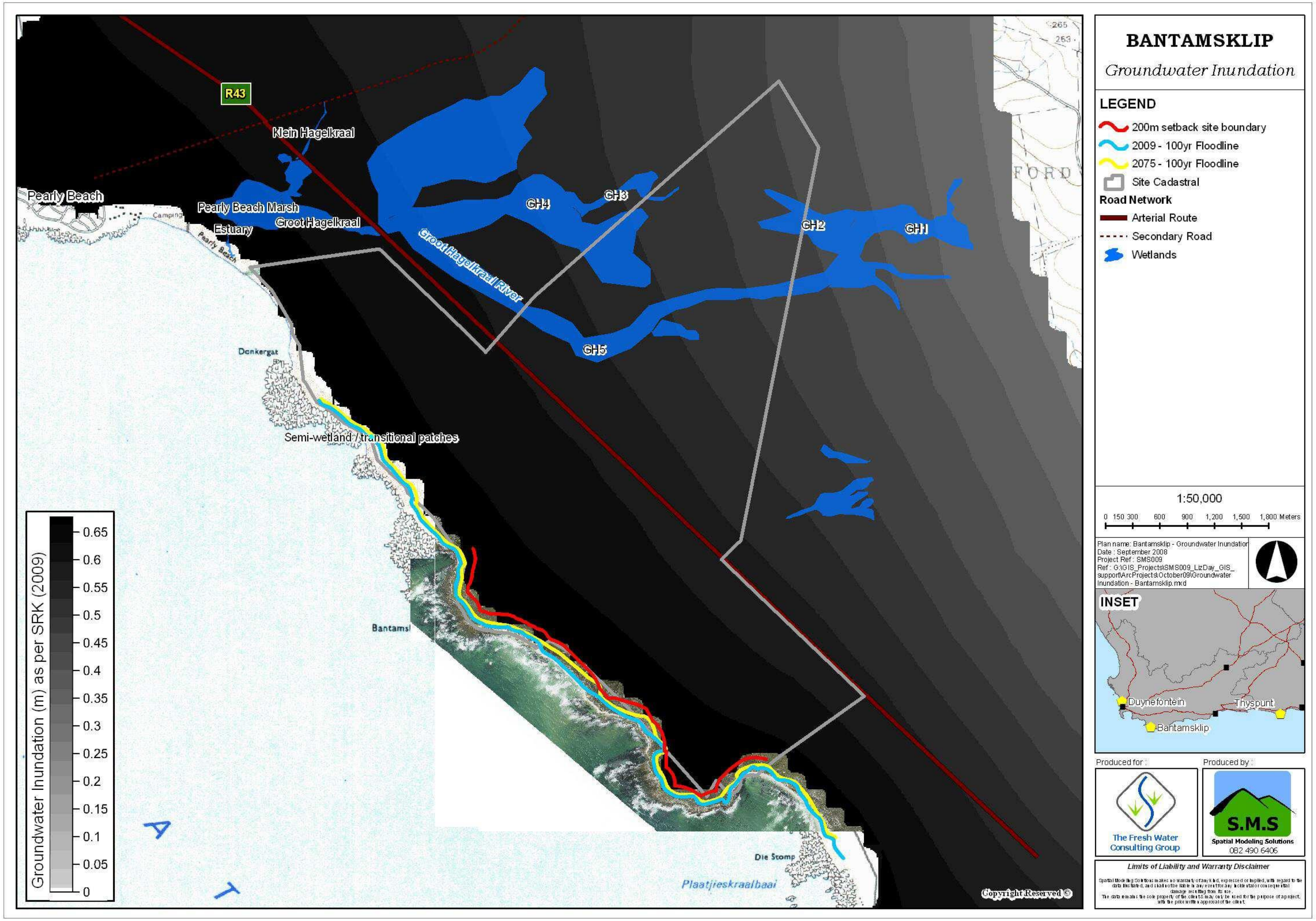


Figure 4.4 **Modelled increase in groundwater at Bantamsklip, assuming a 0.8m increase in sea level. Figure adapted from SRK (2009) Wetlands shown in blue.**

4.4 Impacts associated with development of a Nuclear Power Station at Thyspunt

4.4.1 Overview

Figures 4.5A and B show the conceptual development envelopes and "recommended" development sites for the proposed NPS, as described in Section 3, in the context of wetlands on the Thyspunt site. The latter were derived from the areas of high sensitivity and/or importance, mapped in Figure 4.5A, and comprise two areas within the EIA corridor, both set back from the coast in order to accommodate (primarily) concerns raised by the Heritage specialist. Figure 4.6 also shows both the development envelopes and the "recommended" development areas in the context of the wetlands, but includes the (present) 1: 100 year floodline along the coastal edge, and the estimated floodline in 2075, under the scenario of a 0.8m rise in sea level (as per predictions of the Intergovernmental Panel on climate change report (IPCC 2008). It is assumed that the HV Yard, located as indicated in Figures 4.5A and B, and 4.6, is included as part of the recommended development area.

The relative size of a conceptual Nuclear1 (4000 MW) terrace is shown as a cut-out in Figure 4.5B. This would need to be accommodated somewhere within the "recommended" (or least sensitive) areas shown in the same figure. Although the EIA corridor includes a portion of the largest of the coastal seeps (* in Figure 2.4) and the downstream edge of the Langefonteinvlei, all wetlands have been excluded from the "recommended" development areas shown in Figures 4.5A and B.

In addition to the construction of the NPS itself, various associated activities must also be considered in terms of their potential impact on freshwater ecosystems. These are assessed as separate sections in this assessment, and concern the implications of:

- Management alternatives for sewage generated on the site;
- Options for water supply on the site;
- Different mechanisms for linking the NPS site to the proposed HV yard on the northern side of the site;
- Options for the temporary or long-term storage of spoil and/or topsoil on site;
- Options for the removal of excess sand from the site; and
- Different options for an access road into the Thyspunt site.

Of the above, it is assumed that any long- or short-term storage options for spoil would be accommodated within the recommended development area, and/or the HV yard, and/or disposed of at sea. The EIR report for this study in fact recommends that offshore disposal should be used at all three sites. This would entail short-term storage in a pond on site, prior to pumping the material offshore. There may be limited permanent disposal of the coarser fractions on site (R. Heydenrich, Arcus Gibb, written comments on an earlier draft of this report).

Finally, the implications of climate change for wetland systems, and the relevance of this in terms of the impact assessments outlined in this report, are discussed.

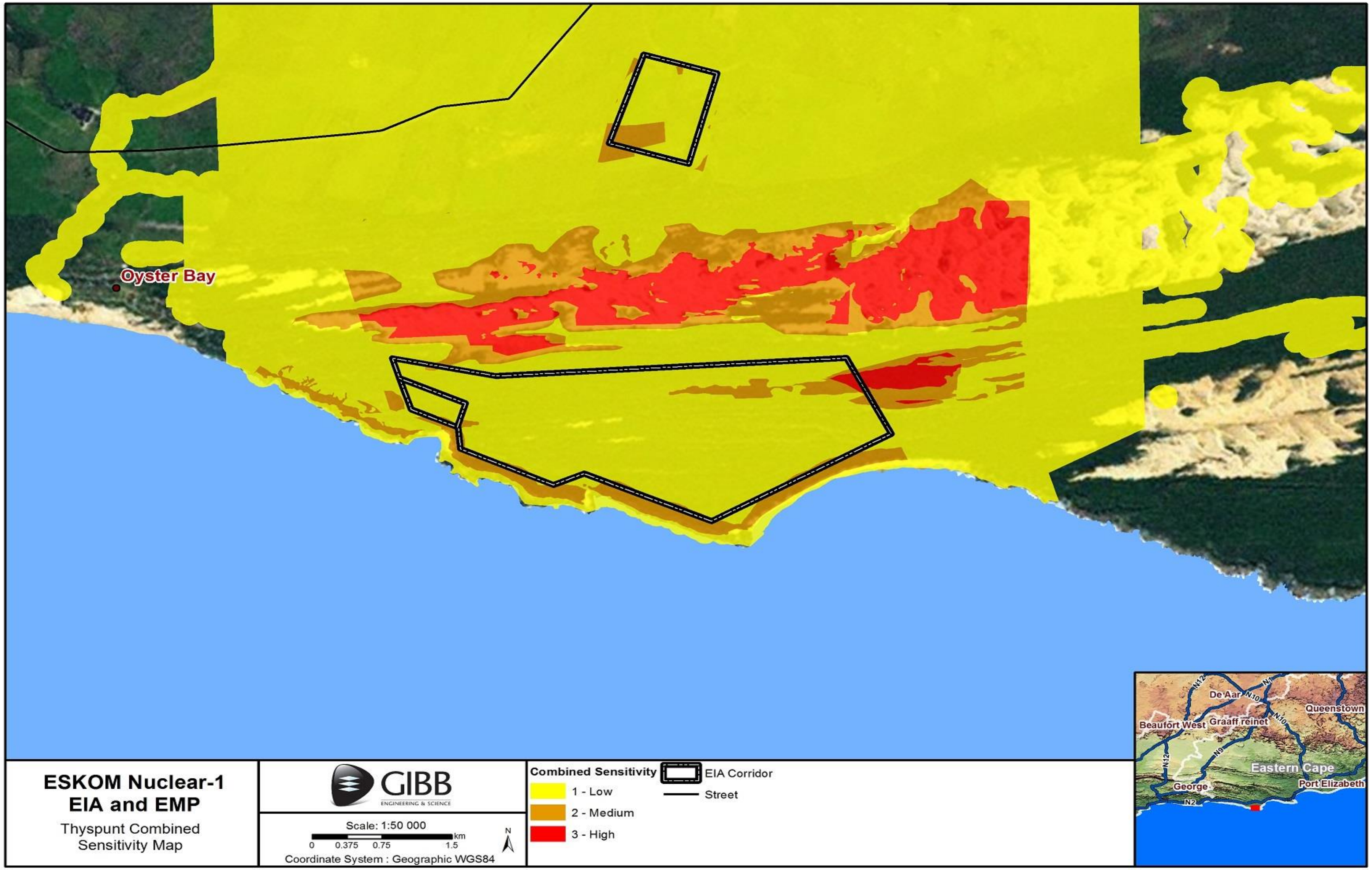


Figure 4.5A **Determination of a least sensitive development area at Thyspunt, based on an overlay of mapped sensitivity areas for different specialist disciplines in the EIA process. Figure courtesy of GIBB.**

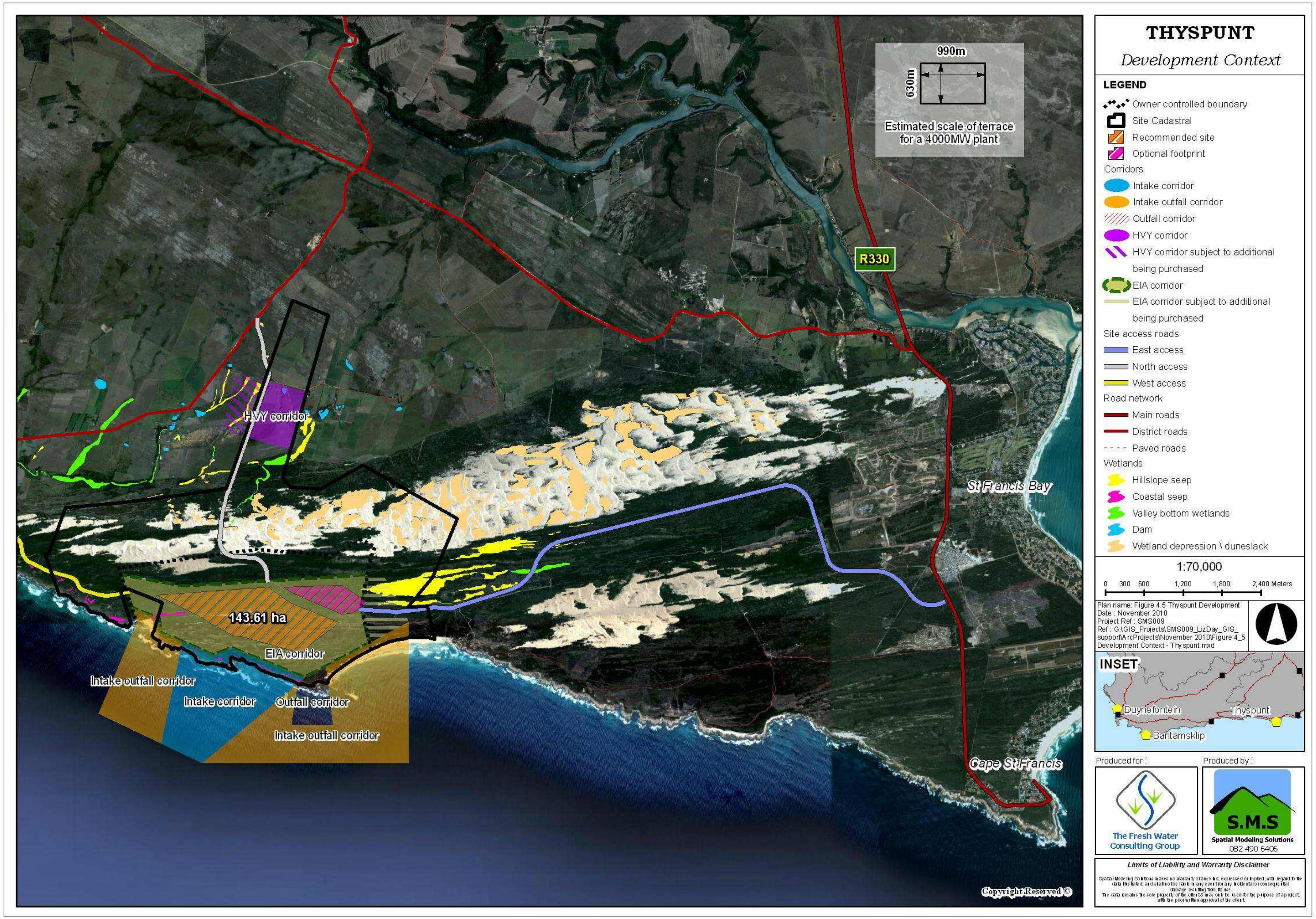


Figure 4.5B **Proposed corridors for the location of different components of an NPS at Thyspunt, showing development corridors and proposed infrastructure in the context of wetlands mapped at the site. Block on right hand corner indicates relative size of conceptual NPS footprint- footprint dimensions courtesy Eskom. "Recommended site" (or least sensitive development area) derived as per Figure 4.5A.**

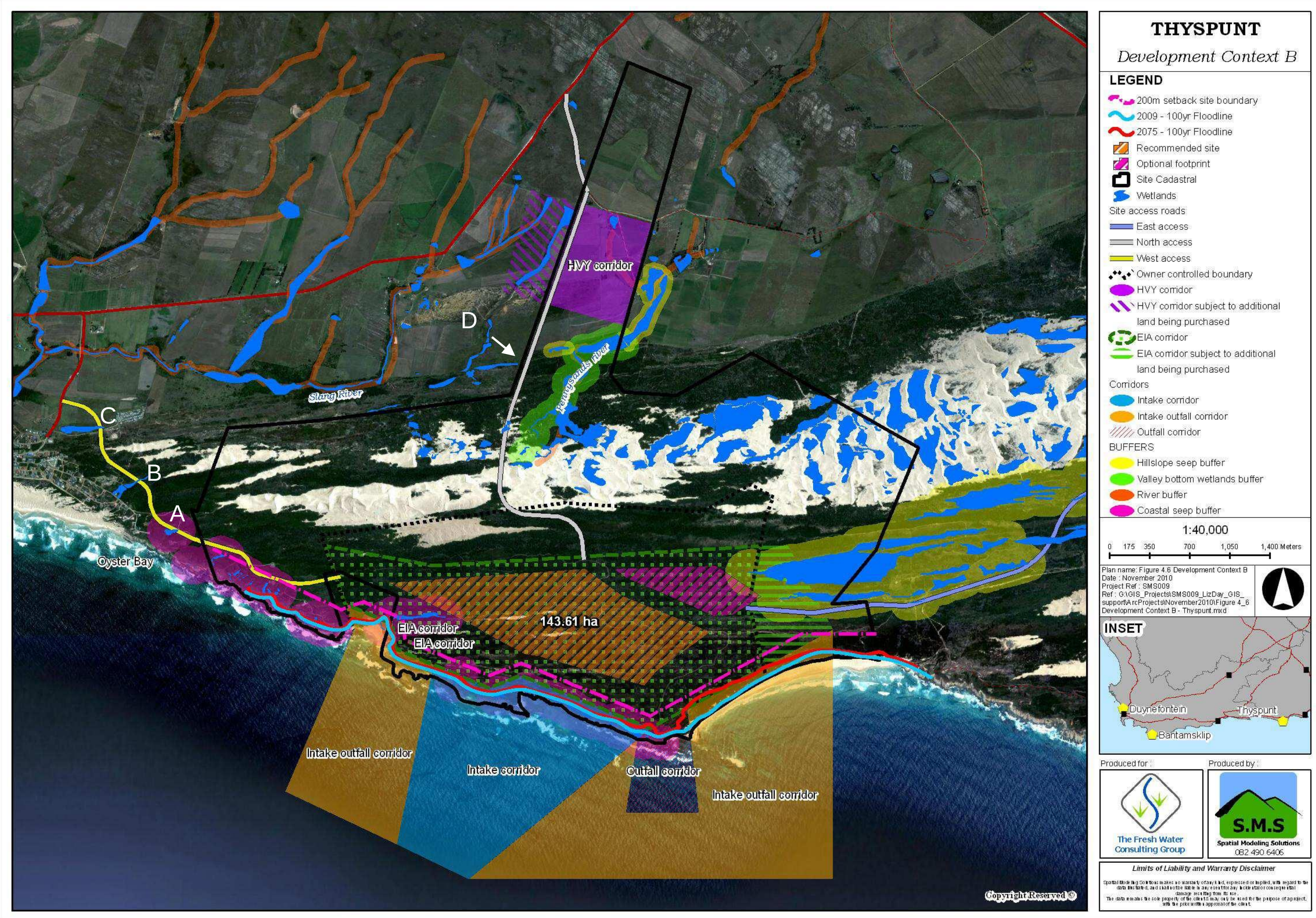


Figure 4.6 Detail of proposed corridors for the potential location of different components of a single NPS at Thyspunt, showing proposed development corridors, "recommended" development site and proposed infrastructure in the context of wetlands mapped at the Thyspunt site.
Areas marked "A", "B", "C", "D", "W and "Z" discussed in text (Section 4.4.9).

4.4.2 Impacts associated with the construction phase of a NPS[7]

Construction of the proposed NPS would involve initial excavation through the dunes to bedrock level. Although the relative size of the terrace is shown in both Figures 3.3 and 4.5B, the actual extent of the construction-phase excavation would probably be considerably larger, allowing for the creation of stable side-slopes in an area characterised by deep sands. The excavation would result in the generation of both sand and rock spoil, of estimated volumes shown in the cut-outs in Figure 3.3. The further north within the EIA corridor that the excavations occur, the greater the volume of sand that would need to be displaced. Dewatering of the excavated site would be an integral aspect of construction activities.

The following impacts to wetlands would be associated with these activities:

A Loss or degradation of dune slack and/or hillslope seep wetlands as a result of dewatering

Excavation to bedrock would require dewatering of the intergranular aquifer, below the water table. Given the fact that groundwater moves through the sands and underlying cobbles at a rapid rate (SRK 2009), dewatering in one area could have a far-reaching impact on the water table in more distant areas of the dune field.

Visser *et al*. (2011) remodelled the impacts of construction-associated drawdown of groundwater, assuming positioning of the Nuclear Island in the “recommended” development area, and with drawdown taking place in the eastern half of the NPS (this scenario was considered by Visser *et al*. (2011) to be more realistic than full draw-down across the whole site). An important aspect of the model was the conclusion reached by Visser *et al*. (2011) on the basis of a year of detailed surface and groundwater data collection, that the southern portion of the Langefonteinvlei, and the western sections of both the southern and the northern portions of the wetland are perched above the groundwater table of the Algoa Aquifer, rather than being linked directly to it. Drawdown caused by abstraction or dewatering extending to below these parts of the wetland is therefore unlikely to have any effect on wetland hydrology or hydroperiod. However, if drawdown extends to the northern and eastern portions of the wetland, wetland hydrology would be affected.

Taking the above into account, the results of the numerical modelling (shown in Figure 4.7A after Visser *et al*. (2011)) indicate that:

- the zone of dewatering could extend to a maximum of 1,8 km from the footprint boundary when dewatering an entire footprint and 1 km when only dewatering half of a footprint. In the latter (more realistic) scenario, dewatering would intercept the western part of the Langefonteinvlei. However, this portion of the wetland is not connected to the water table in this area, although the actual boundary of connection is likely to vary between years.
- the coastal seeps/springs would not be affected by drawdown, although they could be affected if the direct groundwater pathways presently feeding these seeps are interrupted or diverted by dewatering mechanisms (this impact has been assessed separately).

---

[7] Note that impacts associated with the construction phase of access roads to the site are dealt with separately in Section 4.4.10.

Assuming a worst case scenario, in the event that drawdown did result in loss of flows from the eastern and northern portions of the wetland such that wetland hydrology was affected, the impacts could be of long-term significance, depending on their duration and extent. While it is likely that the thick organic layer that underlies the entire wetland would provide a measure of short-term buffering against loss of water to draw-down, such organic layers are sensitive to desiccation and, once drying commences, it is often irreversible, resulting in changes to the hydric properties of the organic sediments. If such changes took place in the Langefonteinvlei, drawdown impacts would result in an irreversible loss of the *Cladium mariscus* wetland habitat and moreover, be associated with a high potential for long-term subsurface fires in desiccated organic sediments. Such impacts could also give rise to head-cut erosion of the wetland, by trickle flows of groundwater across the wetland surface (after Visser *et al*. 2011).

Given the very high ecological importance and irreplaceability of the Langefonteinvlei, and the ongoing uncertainty regarding the actual footprint of a NPS at the site, the possibility of impacts to this system is regarded as an impact of potentially **high negative significance**, in the absence of mitigation measures.

B *Loss or degradation of coastal seep wetlands as a result of interference with surface or groundwater flows, including dewatering activities*

Construction of a NPS on the Thyspunt site as modelled in Figure 4.7A would result in definite loss of a substantial portion of the important coastal seep wetlands, shown in Figure 2.6 and described in Section 2.3. While draw-down modelling suggests that draw-down of coastal seep wetlands would not occur, the installation of the deep Nuclear Island and the terrace itself directly across the flow pathways of groundwater feeding these seeps would deprive existing seeps along the coastline of their source of fresh water. The coastal seeps are at their most extensive in the area between the two beaches, comprising broad swathes of wetland above the rocky shore, and pools of fresh water within the rocky shores.

Not only would some seeps be deprived of groundwater flows, but diversion of groundwater round the NPS would result in concentration of flows on either side of the footprint, potentially resulting in erosion of remaining seeps and a loss of the broad swathes of freshwater seeps that characterise the coast in the vicinity of the proposed site.

Visser *et al.* (2011) also estimate that seawater intrusion as a result of drawdown could affect a 280 m radius area along the coastline, which could impact on some of the coastal seeps. The affected seeps would be least resilient against increased salinities, as they would also be most likely to be impacted by loss of groundwater flows as a result of upstream diversion through dewatering.

Salinisation of wetland soils would be expected to result in rapid die-off of existing wetland communities, which mostly comprise fauna and flora that occur in fresh to mildly brackish systems only. Even short-term salinisation of soils could result in long-term impacts.

Loss of extensive areas of coastal seeps would dramatically decrease the biodiversity value of the coastal zone, by reducing the availability of fresh water in this area, which is thought to play an important role in attracting terrestrial fauna to this part of the site.

These impacts to the coastal seeps as a result of construction of the NPS would result in impacts of high negative significance in terms of wetland ecosystems, with knock-on effects in terms of ecological corridors between the coastal seeps and the Langefonteinvlei wetlands upstream. The further east that the NPS would be located, the more significant would be the impact, as the coastal seeps are least impacted in this portion of the site, between White Point and Thyspunt (Visser *et al*. 2011).

C Degradation of coastal seep wetlands as a result of receipt of concentrated volumes of potentially sediment-rich water from dewatered areas

Depending on where this waste water is disposed of, it could result in sedimentation of downstream coastal seeps or other adjacent wetlands, leading to infilling and a propensity for invasion by weeds and alien vegetation, while concentrated flows of water pumped from dewatered areas could also lead to erosion, channelisation and down cutting of these important systems, and a complete change in their function from broad, groundwater fed seeps to surface-fed, potentially channelised outlets.

These impacts would be considered of medium negative significance.

D Degradation of the western section of the Langefonteinvlei as a result of the proximal location of stockpiles of spoil or topsoil

In addition to the excavated terrace, spoil areas could also be located within the "recommended" development area. However, depending on the size of these stockpiles, their impact could extend into adjacent wetland areas. This section assumes a "worst case" location for such stock piles, within the proximity of the western edge of the Langefonteinvlei, as mapped in Figure 2.6. Such spoil areas could give rise to wind- or water-borne erosion of sediment from spoil piles into adjacent wetlands, effectively infilling portions of the seeps and increasing their vulnerability to invasion by alien vegetation.

Such impacts would potentially result in wetland degradation and a lowering of their high PES, and are thus seen as impacts of low to medium negative significance, although the probability of their occurrence is low.

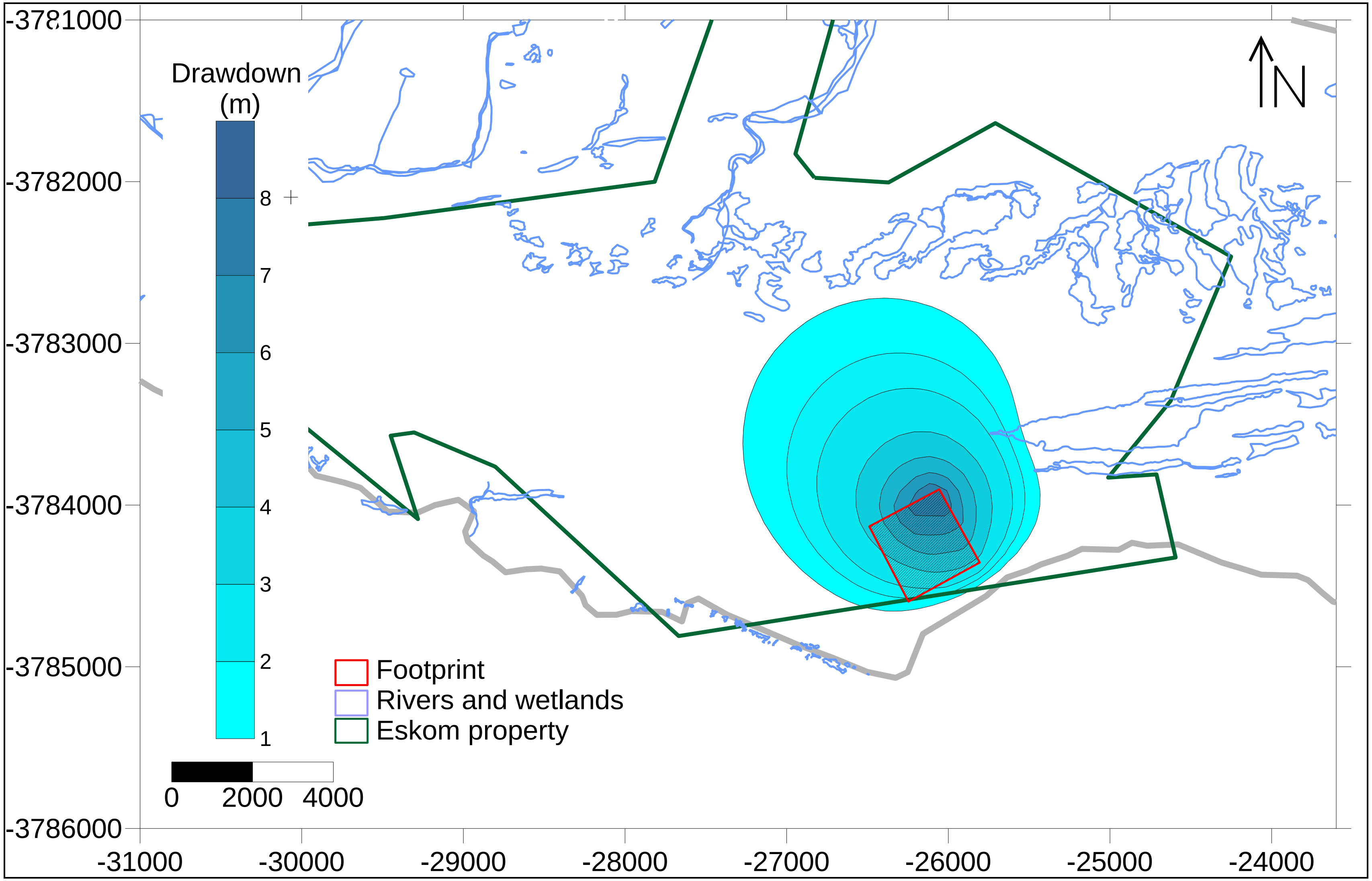


Figure 4.7 **Modelled radius of drawdown at the Thyspunt site, assuming draw-down of eastern half of proposed NPS footprint.** Figure after Visser et al. (2011). . Note that the extent of coastal seeps is not clear at this scale, and Figure 2.6 should be referred to, for a clearer indication of coastal seep extent. Wetlands shown in blue.

A **Draw-down associated with the unmitigated implementation of a 4000 MW plant.**

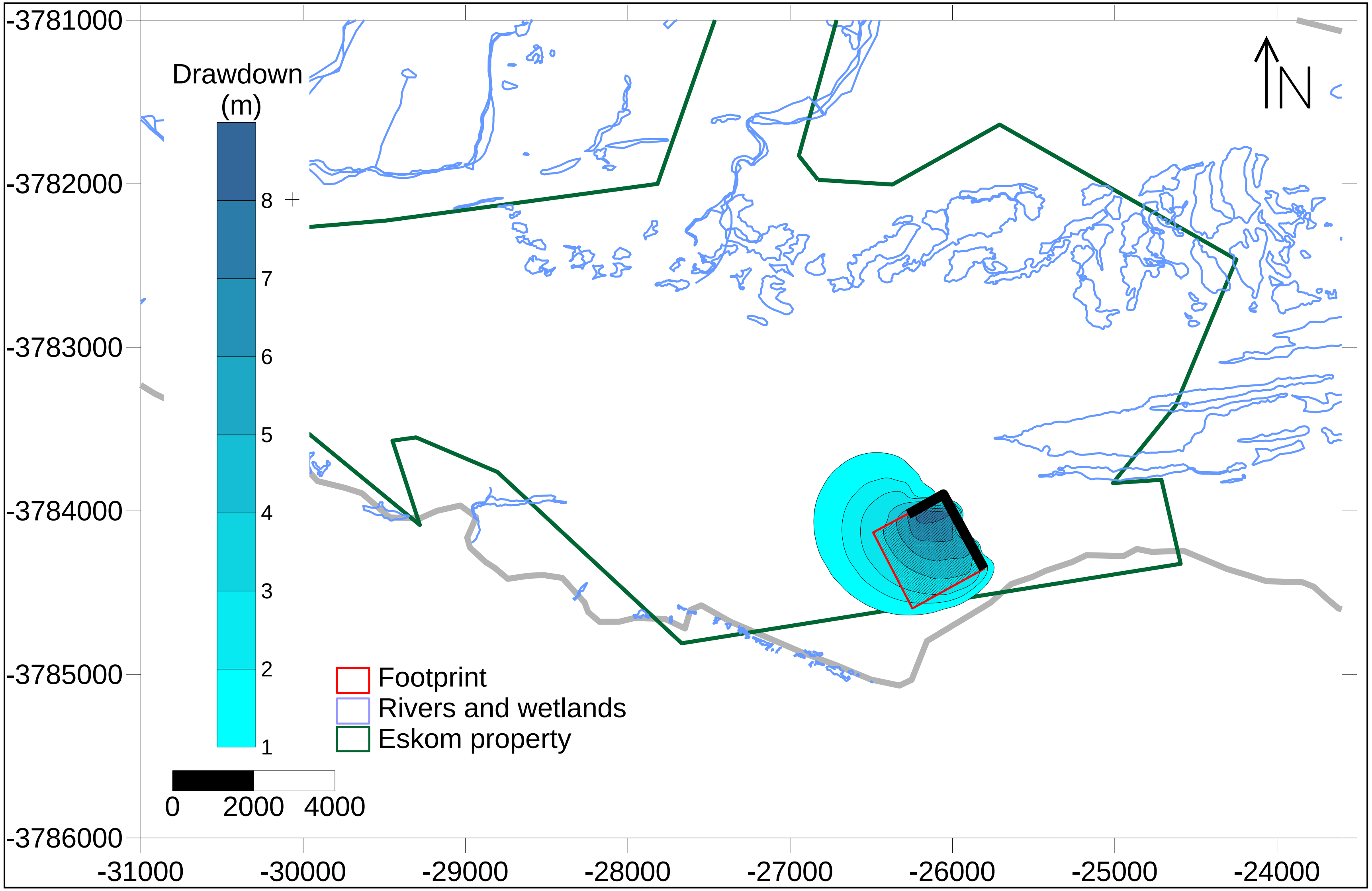


Figure 4.7 **Modelled radius of drawdown at the Thyspunt site, assuming draw-down of eastern half of proposed NPS footprint.** Figure after Visser *et al.* (2011). . Note that the extent of coastal seeps is not clear at this scale, and Figure 2.6 should be referred to, for a clearer indication of coastal seep extent. Wetlands shown in blue.

B **Draw-down associated with the implementation of a 4000 MW plant, with mitigation in the form of a partial cut-off wall (shown as a black line)**

E Degradation of coastal seep wetlands as a result of catchment hardening and runoff from laydown areas

Construction-phase lay down areas on the proposed NPS site would be likely to include substantial areas of hardened surface, and would thus be associated with increased stormwater flows. These flows would potentially include contaminated material from the laydown areas, including hydrocarbons, heavy metals and other pollutants, depending on the nature of materials stored in the laydown and the activities carried on there. Although Eskom (2008c) notes that a stormwater management system that separates "clean" and contaminated runoff would be in place during the operational phase, no system has been specified during construction and it is thus assumed for EIA purposes that an ecologically effective system would not be in place.

Such runoff would be unlikely to affect any of the wetlands near the development platform, with the exception of the coastal seeps, which could be vulnerable to impacts associated with runoff from hardened areas. If runoff was passed directly onto the dunes or slopes leading to these wetlands, rapid infiltration into the lowered water table would occur, and although some water quality amelioration would occur during infiltration, impacts to seepage wetlands that had already been impacted by loss of water could be expected. These impacts would be magnified, as groundwater diversion and dewatering would reduce potential dilution opportunities, and reduce the resilience of the affected wetlands to withstand further impact.

Another impact associated with catchment hardening would be an increase in the velocity of stormwater flows from the site. Although infiltration of runoff into the sand is likely to be rapid, during large scale storm events, erosion of new drainage channels is possible, resulting in erosion nick points and potential degradation of downstream systems exposed to increased sedimentation from eroded areas. It is noted that the specialist hydrology study (SRK 2010) recommends the use of retention ponds to attenuate such flows – these are not however part of the assessed stormwater design.

The above impacts are considered of at least medium negative significance, given the relatively unimpacted condition of the wetlands at present.

F Degradation / drainage / infilling of hillslope seeps and valley bottom wetlands north of the high dune fields

The proposed HV yard would be located in the panhandle area, on the Eskom land north of the Oyster Bay dunefield. The HV yard would be built on a terrace, constructed with sand imported from the Nuclear terrace excavation area (Eskom 2008c). Note that the impacts of transporting the sand to the HV yard (HVY) are outlined in Section 4.4.8.

Figure 4.5B shows that the southern portion of the HV corridor closely abuts the depressional wetland "x", demarcated in Figure 2.6 and described in more detail in Table 2.8 and Section 2.3. This depression lies within the Pennysands River / valley bottom wetland, and forms the northern edge of the wetlands that are considered of higher conservation importance than the multitude of impacted systems that lie within areas utilised intensively for agricultural purposes.

The northern end of the HV corridor includes an area with an artificial dam – the dam supported dense *Wachendorfia* sp. at the time of the September 2009 site visit. An artificial drainage channel passes down the western side of the existing dirt road that runs within the Eskom panhandle towards the dunes. This channel conveys flows towards the valley bottom wetlands leading into the Pennysands depression. , via a hillslope seep, described in Section 2.3 (Table 2.8) as the only hillslope seep noted north of depression "x" which retained significant stands of indigenous vegetation that supported its conveyance of near-surface seepage water down the hillslope.

The following impacts to the above systems would be likely, during the construction phase of the proposed HVY platform:

- Infilling of the artificial dam on the northern portion of the HVY envelope – this impact is considered of low to medium significance – although the dam itself is an artificial excavation, it is associated with a broad area of partially artificial but also possibly natural seep, which is now channelled downstream along the road edge;
- Diversion of channels conveying water into the hillslope seep upstream of depression "x" and likely concentration of their flow into low lying areas – in this case, the hillslope seep described above and the Pennysands depressional wetland;
- Concentration of flow into the above wetlands would be exacerbated by the creation of a large hardened development platform, which would result in increased velocities and volumes of runoff into downstream areas, potentially leading to channelisation within wetlands, down cutting and ecosystem degradation in the hillslope seep wetland. The depressional wetland would be prone to collection of sediment from eroded channels, resulting in the creation of disturbed patches within the wetland, prone to invasion by weedy alien or other invasive terrestrial and wetland plants; and
- Passage of wind and /or water borne sediment from stockpiled sand into wetlands, which would also result in effective infilling of wetlands over time and contribute to their long-term degradation and likelihood of being invaded by alien and other weedy vegetation.
- .

Together, these impacts are considered of medium negative significance in terms of wetland systems.

4.4.3 Impacts associated with the operational phase of the NPS

A Loss or degradation of coastal seep wetlands as a result of interference with surface or groundwater flows

The interference by the proposed NPS and its associated groundwater and stormwater diversion drains with groundwater flows that naturally feed the coastal seeps would be sustained into the operational phase of the development(see Figure 4.7A). Not only would some seeps be deprived of groundwater flows, but diversion of groundwater round the NPS would result in concentration of flows on either side of the footprint, potentially resulting in erosion of remaining seeps and a loss of a substantial portion of the broad swathe of freshwater seep that presently characterises the coast in the vicinity of the proposed site.

The extent of loss of coastal seep wetlands would be greatest if the footprint of the NPS was positioned north of the rocky shore between coastal seep "*" (White Point) and the point, Thyspunt, to the east – the proposed "recommended development area" as modelled in Figure 4.7A lies to the east of this area.

Loss and ongoing degradation of coastal seeps would be considered a permanent impact, of high negative ecological significance.

B Salinisation of coastal seeps

Discussions with Eskom engineers during early phases of this project indicated that, during the operational phase of the NPS, warmed coolant water would flow back to the sea along a water outfall channel, which would not necessarily be lined. Comments from Eskom Nuclear Engineering on the present (2011) version of this report indicate that coolant water will be piped to the surf zone. The issue of coastal seep salinisation is not therefore considered of relevance, and is not assessed further in this report. In the event that the stated pipeline design is changed in the future, this aspect would need to be revisited.

C Degradation of remnant coastal seepage wetlands as a result of receipt of stormwater runoff

Remnant coastal seepage wetlands that survived the impacts of diversion of groundwater, saline inflows and concentration of groundwater outflows in places would also potentially be subject to runoff of concentrated flows of stormwater from hardened areas of the NPS site and its ancillary structures. Eskom (2008c) specify that the detailed design stage for the proposed project would include specifications for the provision of a detailed stormwater management system, which would allow separation of "clean" and "dirty" runoff from the system, with "dirty" runoff being treated in a lined reservoir, and uncontaminated water as well as treated water being discharged into the sea. Although the discharge mechanism has not been specified, it is assumed it would be by way of surface or piped flows to the shore. This means that erosion of coastal seeps as a result of concentrated runoff is possible, where these seeps include sandy slopes rather than wetlands perched on the rock shore. In addition to this impact, the seeps may receive runoff that includes sediment, hydrocarbons or other contaminants that may not be regarded as of poor enough quality to warrant treatment with the dirty runoff, but which nevertheless contribute to a loss of ecosystem integrity, particularly if they accumulate in standing water pools along the coastal area.

These impacts would be considered of low to medium negative significance.

D Degradation of hillslope seeps and valley bottom wetlands north of the high dune fields

The hillslope seeps that occur on the erf immediately east of the panhandle, the Pennysands depression and the Pennysands River itself would all be vulnerable to impacts associated with the receipt of concentrated runoff from the infilled HVY platform, and from "edge" impacts associated with its ongoing use. Such impacts would include:

- Erosion and/or channelisation of hillslope seeps, as a result of receipt of concentrated stormwater flows from the HVY platform, leading to degradation of the presently well-vegetated hillslope seep just east of the site
- Receipt of contaminated stormwater runoff from hardened surfaces on the site – potential contaminants would be likely to include hydrocarbons from parking areas, sediments and potentially heavy metals – these would probably have a low impact on downstream systems, but could contribute over time to wetland degradation, particularly if erosion of hillslope seeps and valley bottom wetlands, and sedimentation of the depressional wetland, resulted in a deterioration in the water quality amelioration properties often attributed these systems

The above impacts have been assessed as of <u>low to medium</u> negative significance.

E Degradation of dune slack wetlands as a result of increased vehicle passage across the dunes

The location of the HV yard and substation on the opposite side of the mobile dunes to the NPS site increases the likelihood that Eskom personnel will take opportunities to drive across the dunes, rather than round the site via the selected access route. Increased vehicle traffic across the dune can result in erosion, dune slumping, damage to wetland vegetation, compaction of some areas and general interference in the probably subtle factors that influence dune morphology and by implication, the formation and sustainability of the dune slack wetlands that form an integral part of the system.

This impact has been evaluated as of at least <u>medium negative significance</u>, due to the ecological importance of the wetlands and their present virtually unimpacted condition and isolation from human activity.

F Conservation of remaining dune slack, coastal seep and valley bottom wetlands on the site

The development of the Thyspunt site for nuclear power provides an opportunity for the conservation of those portions of the site that are not affected by the development to be conserved within an environment in which other kinds of development that threaten these wetlands elsewhere (e.g. housing and resort development) are unlikely to occur. This is a positive aspect of the proposed development. However, its significance must depend on the extent to which important ecosystems on this site are in fact conserved – where the NPS development leads to loss of important and irreplaceable systems, then these will negate the benefits of conservation of remaining areas. Moreover, without an extensive management framework for the operational and ongoing management of the site, effective conservation will not be achieved. Given these caveats, the positive impact of conservation of wetland habitat is assessed to be <u>of low positive significance</u>, without implementation of significant additional mitigation measures.

4.4.4 Impacts associated with sewage management options at Thyspunt

Treatment of sewage would take place on site – the purified water would either be piped to sea or pumped to an evaporation pond (comments from Eskom at 2nd Specialist Integration meeting, 2008). It is assumed that sludge would be disposed of off-site. Scant technical details regarding likely treatment volumes, final effluent quality and disposal methods are, however, currently available to inform this assessment. Passage of treated effluent from the plant to the sea would result in marine ecosystem impacts (presumed to be assessed in the specialist marine report). Disposal of treated effluent in an evaporation pond would enlarge the disturbance footprint of the NPS site, as well as increase possibilities for seepage of nutrient enriched water from the evaporation pond into the aquifer and thence into important coastal systems, including the coastal seeps. Depending on the location of the treatment works and its evaporation ponds, the risk of nutrient enrichment of adjacent wetlands would also vary.

Comments from Eskom Project Management on an earlier version of this report indicated that use of an anaerobic treatment package plant on each site, rather than a plant requiring evaporation ponds, would be the preferred approach to sewage treatment (see Section 3.2.3). Since this does not form part of the formal design documentation presented by Eskom for assessment, the proposal is noted, and referred to again in the relevant mitigation section for this impact.

Without details as to the quality of effluent produced by the plant, and given its proposed location, albeit at a conceptual level, this option would thus, in its present form, be associated with impacts of medium significance to wetland systems.

4.4.5 Impacts associated with different alternatives for fresh water supply on the site

Eskom (2008c) lists the following potential sources of fresh water for the NPS site:

- Abstraction from the Thyspunt aquifers;
- Piping municipal water from the St. Francis Bay feeder line – a pipeline would need to be installed along the proposed access road;
- Piping water from the Orange River scheme – the water could be stored in a reservoir at St. Francis Bay and a pipeline would need to be installed along the proposed access road to the site; and
- Desalination (on-site desalination of sea water using reverse osmosis (RO) technology) as outlined in Section 3.

Given the fact that groundwater on the site would already be manipulated by site dewatering and / or diversion (construction phase and operational phase), and the probable impacts that this could have on at least coastal seep wetland ecosystems, the use of additional sources of groundwater to supply the site with a source of fresh water is considered to be an avoidable impact associated with significant negative consequences, particularly when viewed cumulatively with other impacts. Without a more detailed assessment of the impacts of proposed water use on actual ground water levels, further assessment of this option is difficult, and it is conservatively allocated an assessment rating of medium negative significance. Assuming that authorisation was provided for the overall NPS project at this site, this evaluation could be reviewed at a later stage, once dewatering is complete and the likely sensitivities and trajectories of groundwater-dependent ecosystems had been determined to a high level of confidence based on detailed monitoring data. The use of water from controlled dewatering areas themselves during construction could be considered, provided that the feasibility of recommended wetland mitigation measures (see Section 5) is not affected.

Piping water along the proposed access road is similarly viewed as a negative impact, with the main reason against it being the expansion of the disturbance zone of the road along and across sensitive wetlands. This impact would be associated with an impact of medium negative significance, depending on the exact footprint of the pipeline. Note that indirect impacts to off-site wetlands associated with external water sources are not considered here.

Desalination of sea water as a means of supplying the NPS with fresh water has been assessed as an impact that does not appear to be associated with impacts to freshwater ecosystems, assuming that the plant itself and its associated tanks and reservoirs can be located outside of wetland areas, including the coastal seep areas.

4.4.6 Impacts of different options for linking transmission lines from the NPS to the proposed HV yard

The proposed transmission lines would cross through or over the following wetland areas, shown in Figure 2.6:

- The duneslack wetlands within the mobile dunefield;
- The duneslack depressions and wetland flats adjacent to the dunefield, on the northern dune edge;
- The Pennysands River / valley bottom wetlands; and
- The Pennysands depression (x).

The mobile dune area itself is regarded as a critical support area for the duneslack wetlands and, by virtue of its role in groundwater recharge, for the hillslope seep, valley bottom and coastal seep wetlands identified to the south of the Oyster Bay dunefield.

The following sections outline impacts that would be associated with the proposed transmission lines within the site.

A Impacts associated with the transmission lines

The main source of concern associated with the proposed transmission line routes across the mobile dunes is associated with the need for maintenance roads beneath the transmission lines, rather than the lines and pylons themselves. Access roads would be required to allow vehicle access to towers, both for construction and ongoing maintenance and repair activities. No design details have been provided for the proposed access roads. Such roads could potentially result in:

- significant earth movement during construction, resulting in localised habitat alteration;
- surface compaction, resulting in localised changes in infiltration and dune morphology – given the dynamic nature of the dunefield, these impacts would probably be relatively short-lived, assuming that dune movement was not controlled as a result of the road;
- an increased likelihood of uncontrolled blow-outs occurring in adjacent dunes during and after construction (Illenberger 2010) as a result of local disturbance in a highly dynamic environment;
- the spread of litter and alien plant seed material, transported by vehicles, into the heart of the dunes;
- establishment of an axis from which off-road access to the rest of the mobile dune would be possible, with a concomitant spread of disturbance zones;
- localised disturbance of the dunefields and their wetlands, as a result of concentration of flows off the road (albeit these would be likely to dissipate quickly into surrounding areas)
- increased fragmentation and degradation of a presently largely undisturbed natural area, again at a low intensity, made more noticeable by the present absence of such impacts.

North of the dunes, the transmission lines would pass through a mosaic of depressional wetlands associated with the dune edge, and the Pennysands River itself. Unmitigated passage of the transmission lines through this system is also assumed to be associated with the need for a construction and maintenance access road across the wetland area, resulting in impacts such as channelisation of flows at road crossing points over the Pennysands River and other wetlands and associated wetland fragmentation, as well as disturbance to these systems as a result of the pylon construction process. If pylons are founded in situ, construction-phase impacts such as contamination of wetlands and rivers with gravel and cement would also be possible in the area north of the dunefield.

In light of the above, of the three transmission line and pylons described in Section 3.4.2:

- The unmitigated passage of both the conventional and the dual circuit transmission lines across the dunes and the area to the north of the dunes as far as the HV yard is likely to be associated with impacts of at least <u>medium negative</u> significance, in terms of wetland systems

- Crossing the dunes using the proposed "special structure" would, by contrast, not entail any of the impacts outlined above, provided that such structures would not require access roads across the dunes for maintenance. Illenberger (2009) notes that the use of this structure would thus not have any impact on the mobile dunefield – and by implication, would not have any impact on the duneslack wetlands supported by the dunefield. It should be noted however that the use of the "special structures" is not considered feasible by the Eskom technical team, despite its inclusion as an option for assessment in this study. The structure is thus not formally assessed, and is discounted from further discussion.

B Impacts associated with the transmission towers

The detailed design of the transmission towers themselves has not been finalised. Information provided by the Eskom technical team at the 3rd EIA specialist integration workshop of November 2009 indicated however that each tower would probably have a footprint of 24x24m, with concrete blocks in each corner, in the order of 3x3m each.

Depending on their location and founding depth, these towers could potentially interfere with groundwater movements through both the dunes and in the areas to the north of the dune, impacting at a very local scale on the passage of water between and within wetlands, but also contributing to general wetland degradation.

The use of **dual circuit transmission lines** would be associated with a lower level of impact in this regard than the **conventional transmission lines**. This is because although the former have a shorter maximum span, they would entail only two as opposed to four lines. Thus the number of towers required would be less. However, Eskom has commented that this design may also not be feasible from a safety perspective, as it provides less assurance of continued transmission, in the event that a tower fails / is destroyed (Comment from Eskom Project Management on December 2010 version of this report).

Overall, the impacts associated with the crossing of transmission lines over the mobile dunes and through wetland systems in the area to the north of the dunefields would be associated with impacts of at least medium negative significance, without the implementation of mitigation measures.

4.4.7 Options for the removal of sand spoil from the NPS site

The following conceptual mechanisms for the disposal of excess sand have been suggested (Eskom 2008d):

- Conveyance of sand to the panhandle on the northern side of the dunes, across the sand dunes, using a temporary conveyor belt;
- Hydraulic pumping out to sea (preferred alternative in the EIR).

A combination of these options is likely to be the most feasible approach to the disposal of the large volumes of spoil that will be generated by the excavation associated with the NPS (Eskom 2008d). Of the two options under consideration,, only the first can be assessed from a specialist wetland perspective. The second, which falls within the ambit of marine specialists, is not dealt with further in this report, other than to state that in the (unlikely) event that no impacts of negative significance are associated with this method of sediment disposal, then this alternative would clearly be preferred.

A Conveyance of sand to the panhandle using a temporary conveyor belt

It is assumed that the proposed conveyor belt would be associated with an access road for conveyor belt maintenance during the operation. Given that bulk excavation is estimated to take some 346 days (Spreadsheet provided by Eskom (May 2009): "Nuclear1 typical construction programme.xls"), it is also assumed that conveyance of sand would extend well past this period.

Illenberger (2009) notes that both the conveyor belt supports and the access road will cause impacts to duneslack depressional wetlands but not to the mobile dunefield.

From a wetland perspective, the conveyor belt is likely to be associated with:

- Temporary to permanent disturbance of wetlands and their critical support areas within the dunes, if the conveyor belt and access road are left in the dune after the construction period or if the construction period is extended over several years, so that patterns of dune dynamics (and hence wetland formation) are affected;
- Potentially permanent impacts to the depressional wetlands of the Pennysands River and its associated wetlands, as a result of the passage of a road and conveyor belt through these sensitive systems, Extensive windblown loss of sand during its passage over the dunes and into the northern panhandle is also anticipated – this will result in sedimentation of wetland areas and loss of integrity; and

Impacts associated with the storage of the sediment on the panhandle itself and its construction into a building platform have already been dealt with elsewhere in this report.

The above impacts are considered of high negative significance from a wetland perspective.

4.4.8 Impacts associated with different access road alternatives

Approval for construction of a suitable road access route to the Thyspunt site has been identified as critical to the feasibility of selection of Thyspunt as a potential NPS site. Unlike the other two alternative sites, the portion of the Thyspunt site on which the NPS would potentially be located is separated from both Oyster Bay and St. Francis Bay, the nearest centres, by long stretches of sand and dirt road, some of which are presently passable only by 4x4.

A Description of route alternatives

Three potential access routes have been indicated in Figure 3.4 and are thus considered in this report. They are referred to in this figure as the eastern, western and northern access roads, and their alignments are also indicated in Figure 4.6, in relation to mapped wetlands on and in the vicinity of the Thyspunt site. Note that the EIR recommends that the northern route should not be considered further, given the high levels of ecological and other impacts associated with it.

The alignment of the proposed eastern access road, which enters the site from the R330 in the vicinity of Sea Vista, to Cape St. Francis, was developed iteratively during a number of site visits in 2008, attended by the design engineers, the wetland, botanical, heritage and traffic specialists and Eskom's Estate Manager, Mr Gert Greeff. The western and northern access routes were developed during subsequent stages of the project. Eskom (2008c) describes the purposes of each of the proposed roads as follows:

- eastern access road: to allow access to the site for both construction vehicles and power station personnel – as such, it would be designed to carry the super-load vehicles required during construction; and
- western access road: the road would be designed for access to the site for construction vehicles and power station personnel, but would not be used for the transportation of heavy load plant items [this statement applies to the proposed northern access road too, which is seen as an alternative to the western access road].

A1 Description of the eastern access road alignment

The alignment of the proposed eastern route from the St. Francis Bay Road to Thyspunt has the following characteristics of relevance to wetland systems:

- The eastern portion of the road would pass through largely terrestrial areas but swings north at the eastern boundary of The Dunes guesthouse (Erf 179/745) and cross the eastern sector of the remnant valley bottom wetlands that lead eastward from the Thyspunt boundary (marked X on Figure 4.6). East of this point, development of The Links golf course has taken place across the valley bottom wetland and from here downstream, wide-scale degradation of the Sand River system as a whole occurs (see Section 2.3 for a description of the river / dunes in these reaches). The new road in this area would run some 60-80m west of the existing north-south-aligned dirt road that runs along the western fence boundary of The Links.
- The proposed access road would continue to run north after crossing the wide, braided valley bottom wetland, only swinging towards the south west at the boundary of Erf R/745 – an erf that has approval for the development of a number of clustered residential units along the edge of the valley bottom wetlands, with roads and infrastructure that cross the wetlands themselves (Mr Gert Greeff, Eskom, pers. comm.).
- From here, the proposed road alignment would pass through a largely disturbed and alien-invaded terrestrial area, but with stands of coastal thicket including both juvenile and mature Milkwood trees in places. However, from a wetland perspective, the road in this section would not be associated with any wetland systems until it nears the point marked as "Y" in Figure 4.6. Along this area, relatively narrow, permanently to seasonally saturated hillslope seep wetlands occur, running parallel with the high dunes and the extensive valley bottom wetlands to the south, which extend east of Langefonteinvlei.
  The longitudinal hillslope seeps in the vicinity of "Y" are believed to be mainly groundwater-fed wetlands (see Table 2.8 and Section 2.3), vegetated variously by dense *Imperator cylindrica*, *Psoralea* sp. *Juncus kraussii, Juncus capensis, Cyperus thunbergii, Helichrysum* sp. and stands of *Cladium mariscus*. It is FCG's understanding that the proposed road between The Dunes and area Y would run along the route of the existing dirt road, although the footprint of the new road would be wider than the existing road corridor.
- In the vicinity of the area marked "Y" in Figure 4.6, the proposed road would run initially along the dune-side edge of the wetlands, then would swing sharply to the south, and cut across the valley bottom wetlands shown in Figure 4.6, between "Y" and "Z". These wetlands have been densely invaded by woody alien vegetation (mainly Rooikrantz) but the wetter portions have retained patches of *Carex* sp., *Cladium mariscus* and *Helichrysum* sp.. The wetlands correspond to the Eastern Valley Bottom System, referred to in Section 2.3 and described in Table 2.8. Wetter, low-lying wetland braids are separated by low dunes, which give way on the other side to repeated patterns of these wetland swathes.
- On the main dune ridge on the southern side of the valley bottom wetlands (Z in Figure 4.6), the road would swing south west, and pass on the southern side of the dune ridge, with damp to seasonally saturated swathes of hillslope seep wetlands separated from the road by the dune itself. These wetlands feed into the southern section of the Langefonteinvlei wetlands, via a broad hillside seep.
- The existing dirt track crosses through the dune ridge in the area shown as "W"" in Figure 4.6. The existing crossing has resulted in diversion of natural surface flows from the hillslope seeps and into the disturbed area to the south of the dune,

which includes a small artificial pond that is permanently inundated. The dune slopes downstream of the pond include a minor hillslope seep, which is dominated by *Phragmites australis* reeds.

- Figure 4.6 indicates that the proposed road would run to the north of the existing dirt road alignment from here, passing immediately south of the high vegetated dune that serves as the southern boundary of the large hillslope seep associated with the Langefonteinvlei.
- From here, the road would enter the proposed EIA corridor for the NPS site, and no further details regarding its alignment, or the alignment of minor internal roads, are presently available.

A2 Description of the western access road alignment

The alignment of this road has been presented by Eskom from the western edge of the EIA envelope to its intersection with the gravel access road to Oyster Bay (gravel road 130 – Eskom 2008c) (Figures 3.4, 4.5B and 4.6). The proposed road alignment would have the following characteristics with respect to wetland systems:

- The road would run initially in a north-westerly direction, roughly parallel with the coast (Figure 4.6), and approximately 200m from the shore;
- Although the road would follow the rough alignment of the existing unpaved western access track to the site, in fact its actual alignment would be a straight road, which effectively would necessitate clearing a new section of coastal vegetation in this area;
- The road would cross through the upper reaches of a number of coastal seeps. In the western part of the site, these tend to rise higher up the slopes than do the seeps on the eastern side of the site, near Thysbaai;
- Just west of the Eskom site boundary, the road would swing northward, cutting through the upper reaches of a hillslope seep / coastal seep (A in Figure 4.6), and then passing into the densely vegetated southern edge of the Oyster Bay dune field. The road would pass across the western edge of the dunefield, passing initially through a low point between two dunes, and then crossing a larger hillslope seep. This wetland (B in Figure 4.6) is described in Table 2.8. It supports amongst other plants the regional endemic *Merxmuellera cincta* subsp. *sericea* (IUCN listed as Vulnerable) (Low 2009). It is relatively unimpacted in the reaches that would be crossed by the road, but has been diverted, drained, infilled and channelised within its reaches along the outskirts of Oyster Bay; and
- West of the hillslope seep B, the road would pass over the vegetated (mainly by alien *Acacia saligna*) western edge of the dune field, just missing the start of the mobile, unvegetated area. It would pass down the northern edge of the dune at another relatively low point, and swing westwards, crossing through the edge of a depressional wetland (C in Figure 4.6) and then joining with the main Oyster Bay access road. Wetland C has been impacted by grazing and trampling of cattle. Water quality is probably nutrient enriched. The wetland supported stands of *Bulboschoenus maritimus* and *Typha capensis* in shallow standing water, at the time of the September 2009 site visit.

A3 Description of the northern access road alignment

- The alignment for this road as presented for assessment would start on the northern edge of the EIA corridor, due south of the panhandle area (Figures 3.4 and 4.6).

- From here, it would pass north and then west through dense coastal forest and /or stands of alien vegetation, and then swing sharply north, to cross mobile dunes some 30 m in height (Illenberger 2009).
- North of the mobile dune field, the road would pass through at least one depressional wetland associated with the ponding of flows from the Pennysands River against the northern edge of the dunefield. These wetlands are considered of high conservation importance.
- From here, the road would run across the western boundary of the panhandle, and then turn north west, along the existing dirt road that leads to the main Oyster Bay access road.

B Generic road design

The following details were provided to specialists by the Aurecon road engineers with regard to the design of the eastern access road:

- The road would be raised about 1m off the existing ground level, to prevent flooding. Culverts and/or pipes would be installed beneath the road, to allow existing flow corridors to be maintained on either side of the road.
- In wetland areas, the road would be elevated and a number of culverts provided under the road, to ensure spread of flows.
- In the vicinity of the "Dunes" property, immediately upstream of the golf course development, construction of a retention pond would allow management of peak flood flows, to reduce the risk of flood damage to the downstream development.

Information provided to specialists during the assessment phase of this report indicated that the final road width for all of the options is likely to be based on a single lane road, of width (including curbing) up to 22m (Email of K. Neethling, Arcus GIBB to specialists: 7 October 2009). Subsequent input from Eskom Project Management (comments on February 2011 version of this report) suggest that in some cases a 60 – 100 m wide disturbance corridor may be necessary to accommodate cut and fill. It should be noted that such a disturbance corridor has **not** been assessed in this report, and deviations from the assessed 22m corridor may change both the significance ratings and the recommended mitigation measures outlined in this report. Such deviations would require formal re-assessment and comment, if required to be included in the assessed road design. **Please refer to Appendix E31 of the EIR report for an updated assessment regarding the access roads to the Thyspunt site.**

C Impacts to wetlands associated with the construction and use of the proposed road alternatives

i. General impacts to wetlands resulting from road construction and use: all options

This section outlines the impacts that are likely to accrue to wetlands located within the vicinity of any of the proposed new roads, with affected wetlands in this case being defined as those up to 50m from the proposed road edge, or those that are located downstream of the proposed road, such that they are likely to receive runoff from the road. The 50m width is a somewhat conservative value, based on the theory that the generally low level of anthropogenic impact that has affected most of the wetlands described on and associated with the Thyspunt site, is likely to result in greater sensitivity of these wetlands to future impacts. That is, they are likely to undergo changes in function or structure as a result of relatively minor impacts. The

50m zone assumes that up to 10m on either side of the road would be disturbed during construction.

- Construction phase impacts could include:
    - Changes in water quality – runoff into wetlands from roads during the construction phase is potentially associated with high loads of sediment, gravel and other construction-related material, which can affect water quality as well as, more significantly, result in sedimentation of adjacent wetlands, and hence the creation of disturbed areas, prone to alien invasion
    - Disturbance and pollution of wetlands as a result of littering, faecal contamination and trampling by construction workers
    - Compaction, destruction of vegetation and changes in subtle flow pathways along wetlands as a result of the passage of construction vehicles over wetlands.
- Operational phase impacts could include:
    - Scour or erosion, as a result of increased flow volumes and velocities off hardened surfaces – the sandy conditions at the Thyspunt site mean that this impact is likely to occur at a very local level, and to dissipate quickly
    - Changes in water quality – road runoff can be a source of pollution to adjacent wetland systems, with runoff of hydrocarbons, heavy metals and sediment being the major elements
    - Disruption to faunal corridors – roads can reduce the value of longitudinal wetlands as corridors for faunal movement. Such corridors become progressively more important in a developed context, as disturbance increases, and they can be used by both wetland-associated and terrestrial fauna. Roads disrupt these corridors by increasing the danger of terrestrial crossings (e.g. small to medium sized mammals may be killed by vehicles) and by making their use unappealing (e.g. some fauna do not willingly use small, dark culverts to move beneath roads)
    - Disruption to drainage lines – disruption of even minor drainage lines by diversion of flow into larger drainage lines, or to flow along the road edge, rather than across the road, can result in more significant downstream impacts. These include concentration of flows into naturally small channels, resulting in erosion and channelisation and reduction in downstream flows in other channels, resulting in shrinkage of these systems.

The above impacts would apply to all of the wetlands described in Section A (1-3) – both those crossed by the proposed roads and those in their vicinity. Both the generic construction and operational phase impacts would be associated with at least a **medium level of negative significance**.

ii. *Impacts associated with wetland crossings*

The following impacts would be associated with areas where the proposed roads cross existing wetland:

- Infilling of sections of the wetland - the current design is based on the use of culverts to convey flow beneath such road crossings, with the wetlands being infilled across the width of the road. Infilling of wetlands results in loss of wetland habitat across the infilled area.

- Disruption of surface flow patterns both up- and downstream of crossings, with high flow likely to result in turbulence and scour upstream (at least in valley bottom wetlands), while concentration of flows downstream of culverts and pipes often results in channelisation and downstream erosion.
- Interruption to the natural spread of shallow subsurface and surface flows across the wetland, with culverts channelising flows and increasing the likelihood of channelisation
- Fragmentation of wetland habitat and interruption of movement corridors up and downstream for small wetland and wetland-associated fauna. In this regard it should be noted that a road, even with culverts, can offer a substantial barrier to faunal movement
- Disturbance of wetland geomorphology – construction of the roads is understood to require a disturbance area of at least 20m, in which extensive physical disturbance would occur, including destruction of wetland vegetation as well as minor and major channels.

The proposed road alignments would require infilling of wetlands at the following locations (based on the assumption that the road would not bridge these wetlands):
The **eastern** access road would entail infilling:

- A portion of the Eastern Valley Bottom Wetlands at X (Figure 4.6) – the proposed crossing point would pass over the last section of this wetland that is still relatively intact in terms of its geomorphology, before it is diverted, infilled and drained within the downstream erven;
- Portions of the minor hillslope seeps in the vicinity of Y (Figure 4.6); and
- The broad swathe of braided valley bottom wetland, densely invaded by alien vegetation, between Y and Z (Figure 4.6),. The proposed road alignment would not follow any existing road footprint, and would thus result in fragmentation of an extent of valley bottom wetland that presently passes uninterrupted as far as the road crossing at X.

- The **western** access road would entail infilling the upper reaches of the hillslope / coastal seeps outlined in Section 4.4.9A2.
- The **northern** access road would entail infilling duneslack depressions within and immediately north of the Oyster Bay dunefield.

Infilling of the ecologically important, largely unimpacted wetlands that occur on and near to the Thyspunt site, and the impacts on wetland function and habitat quality that would be associated with this infilling, has been assessed as a negative impact of <u>high ecological significance</u>. This assessment applies to all of the road alternatives.

iii. *<u>Impacts to wetlands associated with crossing the mobile dune by road</u>*

Construction of the northern access road would be likely to be associated with at least the following ecological impacts, most of which stem from the physical disturbance of the dune / wetland mosaic within the dunefield during both construction and operational phases:

- significant earth movement during construction, resulting in localised habitat alteration;
- the spread of construction materials (gravel, other road materials) across a broad disturbance corridor during construction but potentially remaining on site in the long term;

- surface compaction, resulting in localised changes in infiltration and dune morphology – given the dynamic nature of the dunefield, these impacts would probably be relatively short-lived, assuming that dune movement was not controlled as a result of the road;
- infilling of wetland depressions where the road crosses through depressional wetlands, and the subsequent loss of important, near-pristine wetlands, particularly along the northern edge of the dunefield;
- interruptions in the long-term west-east migration of temporary wetlands through the dunefield;
- an increased likelihood of uncontrolled blow-outs occurring in adjacent dunes during and after construction (Illenberger 2010) as a result of local disturbance in a highly dynamic environment;
- localised changes in runoff characteristics as a result of the wide swathe of hardened surface comprising the road, resulting in concentrated flows into adjacent areas of the dunefields as well as wetlands along the northern side of the dunefield;
- infilling of sections of the wetland - the current design is based on the use of culverts to convey flow beneath such road crossings, with the wetlands being infilled across the width of the road. Infilling of wetlands results in loss of wetland habitat across the infilled area;
- disruption of surface flow patterns both up- and downstream of crossings, with high flow likely to result in turbulence and scour upstream (at least in valley bottom wetlands), while concentration of flows downstream of culverts and pipes often results in channelisation and downstream erosion;
- interruption to the natural spread of shallow subsurface and surface flows across wetlands, with culverts channelising flows and increasing the likelihood of channelisation;
- localised pollution as a result of road use over time (although high levels of contamination from oils and greases associated with the long-term heavy vehicle road use are not likely, the pristine water quality of the duneslack wetlands in particular means that the relative impact of low levels of contamination could be significant, albeit restricted to areas in the vicinity of the road)
- the spread of litter and alien plant seed material, transported by vehicles, into the heart of the dunes;
- establishment of an axis from which off-road access to the rest of the mobile dune would be possible, with a concomitant spread of disturbance zones;
- a shift in the management priorities for the dune area from a focus on biodiversity conservation to objectives that must give precedence to activities required for road maintenance. Such activities would include the permanent need to manage the spread of windblown sand across the road;
- ecological fragmentation at a system level of a complex habitat (dunefield / wetland / coastal forest / fynbos mosaic) as a result of the long-term use of the road; the rouad would be associated with mortalities of fauna moving through the area, affecting localised migration of frogs and other small wetland and dune fauna between wetlands and dune habitats, to more extensive movements by larger fauna (caracal, leopard, various ungulates) between the dunes and feeding and/or watering areas along the coast and within other wetlands such as the Langefonteinvlei.

The exceptionally low levels of existing impact to the wetlands and dunes within the mobile dunefield mean that any, even relatively trivial, impacts could result in a significant change in the ecological integrity of the system, and a shift in present ecological status from reference condition, to a more impacted level. The impacts outlined above, which would be associated with the construction and ongoing use of a road across the central, least-impacted portion of the mobile dune are not trivial, and the implementation of the proposed northern road would be considered of highly significant negative biodiversity consequences.

Some of the above comments (mainly those around changes in substrate type, runoff, compaction and pollution) apply to both the northern and the western access routes, although it is presently most pertinent with regard to the northern route. Illenberger (2009) does not consider that the proposed western access route across the western tip of the mobile dune is likely to be associated with impacts to dune dynamics. However, in a scenario of climate change, when sea level rises and wind strength increases, dune mobility may increase in the western section (see Section 4.4.14). This would be exacerbated by alien clearing in this area.

4.4.9 Cumulative impacts associated with the NPS development at Thyspunt

The cumulative impact of the proposed NSP development and its associated pylons (within the site) and access roads, even assuming in each case that the alternative that is associated with the least ecological impact in terms of wetland systems is selected, would be of **high negative significance**, resulting in loss of individual wetlands and net degradation of a wetland system of international conservation importance, that is considered a one-of-a-kind system.

4.4.10 The implications of climate change for wetlands at Thyspunt in a development context

The following factors, described by other specialist studies including those of the specialist climatologists engaged in this project (Prestedge et al. 2009 and PRDW 2008), have been considered in the assessment of the impact of climate change on wetlands at Thyspunt:

- Average temperatures at Thyspunt are expected to rise between 1.5 and 2.2º C. CSAG (2007) suggests that this would be associated with greater temperature extremes, with potential increases in summer rainfall intensity at the Thyspunt site.

  Wetland perspective:
  Increased temperatures could decrease the resilience of wetlands to anthropomorphological stresses, such as pollution, physical disturbance; channelisation and water abstraction.

- PRDW (2008), summarises estimated changes in key oceanographic parameters at the Thyspunt site, over the next 90 to 100 years as follows:
    - 0.6m increase in sea level – note however that the IPCC predict an increase of 0.8m, and the latter figure has been used throughout the EIA documentation between specialists, as the projected sea level increase;
    - 10% increase in wind speeds;
    - 17% increase in wave height;
    - 3ºC increase in sea temperature; and
    - 21% increase in storm surge.

  Wetland perspective:
    - Coastal wetlands (i.e. the coastal seeps) could, with climate change, be exposed to higher waves and surges, increasing the extent and potentially the frequency at which the seeps are impacted by salt water conditions during storms;
    - Increased wind speeds could increase dune mobility, potentially increasing the rate of change in unvegetated duneslack wetlands in the dunefield;
    - Assuming a 0.8 m rise in sea-level, it is anticipated that the lower reaches of substantial portions of the coastal seep wetlands would become saline, resulting in loss of the freshwater plant communities that presently characterise these areas; and
    - Along the eastern part of the coast on the site, adjacent to the Thyspunt itself, where deep freshwater pools are located just above the high water splash zone, it is likely that these pools would give way

to saltwater pools, resulting in a decrease in the availability of freshwater pools for use by terrestrial and freshwater wetland fauna.

Figure 4.8 allows comparison of the modelled changes in the projected 1:100 year floodline between the present (2009 line) and 2075 – a time period that would span a 60 year operational phase of a single NPS at the Thyspunt site, assuming a construction date of 2015 (metadata for GIS data from Prestedge *et al* 2009).

Wetland perspective:
Close assessment of the Prestedge *et al.* (2009) floodlines indicates that the 2075 floodline could extend between 10 and 40 m further onto the coast than the present floodline – this means that its extent along coastal seeps would be similarly far-reaching, exposing them to erosion and the stresses of saline waters. Floodlines that extent beyond the rocky shore into the low dunes along the coast may result in erosion of these areas – wetlands that are stressed by increased salinities and/or reduction in freshwater flows may be more vulnerable to erosion

SRK (2009) modelled the extent of groundwater inundation that would be expected as a result of increased sea levels. These data have been projected onto a map showing the locations of wetlands on the Thyspunt site (Figure 4.8). The increase in groundwater level would be to a maximum of 0.55m, confined to approximately 350m inland from the coastline (SRK 2009).

Wetland perspective:

- Figure 4.8 indicates that although the zone of increase in groundwater level would extend to the Langefonteinvlei wetlands, the projected rise in groundwater level is up to 10cm – this may lead to changes in plant zonation, including an expansion of species such as *Cladium mariscus* into areas presently dominated by vegetation such as *Juncus kraussii;* and
- The increase in groundwater level along the coastal areas may result in the establishment of freshwater coastal seep wetlands within zones of elevated groundwater – the habitats are however likely to comprise mainly seeps on slopes, rather than the seeps into pools which characterise much of the Thyspunt coastal seep habitats at present.

New (2002) (cited in Dallas and Rivers-Moore 2008) estimated that over the next twenty years, the most likely changes in regional water supply in the south western regions of South Africa would include an average reduction in streamflow of around 0.32% per annum.

Wetland perspective:
A decrease in streamflow as a result of reduced precipitation may mean, at the Thyspunt site, that hillslope seeps and valley bottom wetlands that currently feed into the Oyster Bay dune field (e.g. the Pennysands system) may experience reduced flows, resulting in long-term shrinkage of wetlands along the northern edge of the dunefield, and potentially placing some of the wetlands within the dune field closer to threshold conditions where they no longer sustain wetland ecosystems.

Summary of likely implications of climate change for Thyspunt wetlands

The wetlands on the site most likely to be affected by climate change would be the coastal seep wetlands, which would be vulnerable to degradation from more frequent exposure to salt water; wave erosion and salt water intrusion, causing vegetation die-back. There is a possibility that wetland vegetation might re-establish further back from the coastline, as groundwater levels increase. The degree to which this occurred would in part be determined by the resilience of the existing systems, which would provide source areas for colonising propagules. Due in part to their limited capacity for adaptation, wetlands are in fact considered among the most vulnerable ecosystems to climate change (IPCC 2008).

Management of coastal seeps such that they retained integrity and thus increased their resilience against climate change impacts would be considered an important aspect that would play a role in determining the extent to which an upward migration of coastal wetlands could occur in the future. This means that impacts such as loss of freshwater inflows as a result of dewatering and the proximal location of the NPS would assume greater significance, in the context of climate change. Eskom's requirement to maintain draw-down in the vicinity of the power plant to "some metres" below the level of the terrace (currently situated at +10 mamsl) during the life of the power plant (Eskom 2009) could, depending on the actual level specified, result in a situation where ongoing draw-down negates the effect of groundwater rise, and its potential for the re-establishment of freshwater coastal seeps slightly higher up the slopes, and results in fresh water emerging from the cobble aquifer only within the salt water zone.

The duneslack depressions may be affected by increased mobility, resulting from increases in wind intensity, while the potential for episodic debris flows may also increase, if the intensity of summer time rains increases.

At the same time, inflows of fresh water into the dunefields from the northern hillslope seeps and valley bottom wetlands may decrease, resulting in shrinkage of vegetated wetlands along the northern dune edge, and the development of increasingly ephemeral duneslack wetlands.

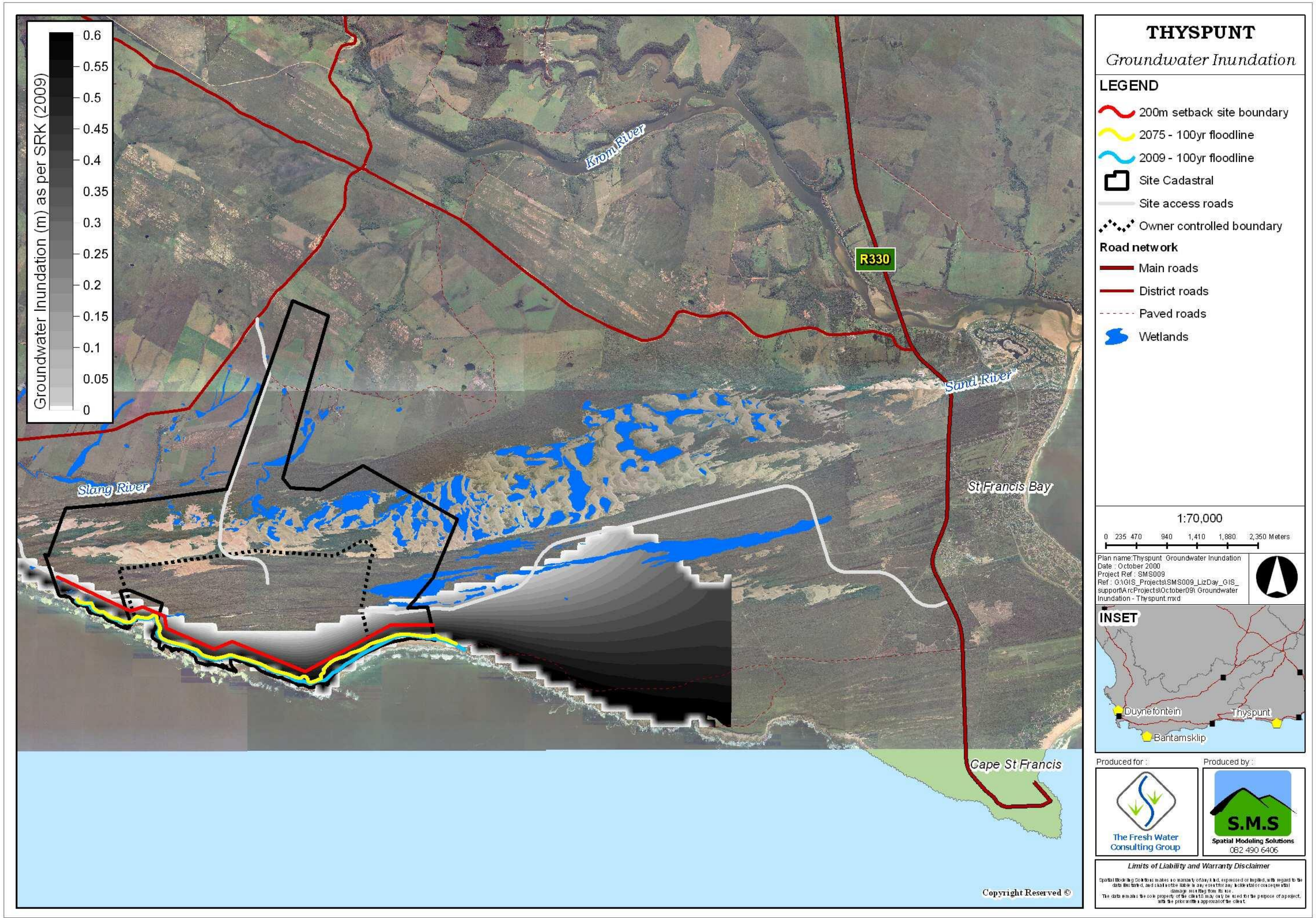


Figure 4.8 **Modelled increase in groundwater at Thyspunt, assuming a 0.8m increase in sea level. Figure adapted from SRK (2009) data. Note that the extent of coastal seeps is not clear at this scale, and Figure 2.6 should be referred to, for a clearer indication of coastal seep extent. Wetlands shown in blue.**

5 RECOMMENDED MITIGATION MEASURES

5.1 Approach to setting and evaluating mitigation measures

This section outlines a range of measures that have been recommended as a means of mitigating against the impacts that have been identified in Section 4. The efficacy of recommended mitigation measures to reduce the potential impacts of the development are assessed formally in Section 6, in comparison with the significance of each unmitigated impact or suite of impacts .

The following hierarchy has been applied in evaluating the efficacy of each mitigation measure:

- Level 1 - Avoidance: impact is prevented or substantially prevented (most preferred)
- Level 2 - Reduction: impact in reduced in magnitude and/or significance
- Level 3- Rectification: impact is mitigated after it has occurred, e.g. rehabilitation of areas disturbed by construction
- Level 4 - Compensation: providing a substitute resource for a resource that has been lost because of the project (e.g., “conservation offsets”)
- Level 5 ***- No action*** (least preferred).

The most effective form of impact mitigation is usually mitigation that results in complete avoidance of the impact. The “no action” approach implies that there is no effective mitigation against a particular impact, including the use of compensation offsets.

The effects of mitigation measures on the assessed significance for wetlands of implementation of various aspects of the proposed developments at the different sites are summarised in Tables 5.1, 5.3 and 5.5.

5.2 Recommended mitigation measures: Duynefontein

5.2.1 General mitigation against loss or degradation of wetlands associated with site layout

A The establishment of "no go" development areas within the site

The setting of "no development" areas on site is considered essential mitigation, and requires consideration of both surface and groundwater interactions between wetlands and development-related activities on the site.

The following restrictions on layout within the site as a whole are recommended, and have in fact been incorporated into the identification of the "preferred development layout" shown in Figure 4.1B:

i. All areas outside of the EIA and the HV corridors are considered in this study as "no development" areas, with the exception of the proposed access road routes indicated in Figure 4.1B. The portions of the areas outside of the two corridors that are of particular relevance to wetland ecosystem conservation and management comprise however:
    - the seasonal wetlands south of the existing Koeberg NPS (that is, the mosaic wetlands that include Sw1 and Sw2)
    - the seasonal and permanent wetlands east of the Koeberg NPS (that is, Sw3, Sw4, Sw5 and Sw6, P1, P4, P5, P6, P7, P2b, c and d
    - undeveloped terrestrial areas that link these wetlands – Harrison et al (2009) recommend faunal corridors across the site, and these should be implemented between wetland areas.
ii. Within the HV corridor: development should ensure that the integrity of the remnant mobile dunes is not impacted by expansion of development into this area, thus destroying existing and potential duneslack wetlands, such as Sw7; and
iii. Within the EIA corridor: development north into the mobile dune would impact on the flux in establishment and loss of seasonal wetlands in the dune, depending on changes in the level of interdune areas; development north of the dune would impact on the present function of the artificial recharge ponds (P3a-d) – the location of these ponds is considered important from a functional perspective, in terms of acting as a hydraulic barrier to seawater intrusion into the aquifer, and thus although they are artificial, their reconstruction elsewhere may not address this function.

The areas specified above (i-iii) should not be utilised as construction laydown, stockpile, spoil or other activities associated with the construction phase of a NPS. From a wetland perspective, however, the wetlands within the EIA and HV yards are not as important as the more extensive, least-impacted wetlands south of the Koeberg NPS. Thus implementation of the recommended development exclusion areas outlined in (i (above)) is considered of higher priority than implementation of the remaining two exclusion areas.

5.2.2 Mitigation against construction phase impacts

A Loss or degradation of seasonal wetlands as a result of dewatering

Although this impact is considered improbable, the following checks and balances are considered essential:

- As a precautionary measure, the use of an impermeable or semi-permeable membrane to limit the radius of draw-down, as recommended by Visser *et al*. (2011) would be supported by this study. In addition, remodelling of the radius of draw-down by the geohydrological team should take place, once a preferred footprint has been decided on for this site, to confirm the assumed limited impact of dewatering on wetlands and allow fine-tuning of the dewatering approach.
- Initiation and ongoing monitoring of surface/groundwater interactions affecting seasonal wetlands on the site is recommended to ensure that this assumption is correct. This information will also inform decisions around the likely impact associated with implementation of any additional NPS development phases at this site.

B Impacts associated with seawater contamination as a result of dewatering

This impact is considered improbable and no mitigatory action is required.

Initiation and ongoing monitoring of surface/groundwater interactions affecting seasonal wetlands on the site is recommended to ensure that this assumption is correct. This information will also inform decisions around the likely impact associated with implementation of any additional NPS development phases at this site.

C *Loss or degradation of seasonal wetlands as a result of construction of internal access roads*

An environmental programme for the site development should include detailed construction-phase specifications around methods to protect wetland Sw5 from impacts associated with the siting of laydown areas and stockpiles for road materials and vehicle access routes. Key to these measures should be the formal demarcation of no-go areas outside of the minimum disturbance area required for the construction of the road. Since the wetland in question lies some 200m from the present road edge, these recommendations are considered technically feasible.

5.2.3 Mitigation against operational phase impacts

A Degradation and/or fragmentation of seasonal wetlands as a result of operational phase use of internal access roads

The following mitigation measures are aimed at impact reduction:

i. Design roads such that runoff is dissipated in side drains / swales, rather than concentrated in lined channels;
ii. Landscape swales such that they resemble more natural seasonal wetlands (e.g. Sw4, created during construction of the existing Koeberg NPS access road).
iii. Ensure that spillage of fuels / other contaminants on the internal roads is dealt with in terms of Best Practice, and not allowed to flow into adjacent wetlands and aquifers.

5.2.4 Cumulative impacts of the construction and operational phases of the NPS and its associated activities, assuming mitigation

The cumulative impacts of the proposed NPS development on wetlands at Duynefontein are likely to be low, assuming that all of the mitigation measures outlined in this section are implemented.

Table 5.1 Assessment of impacts to wetlands as a result of development of a nuclear power station at Duynefontein

Impacts as described in Section 4, with assessment with mitigation based on implementation of full mitigation measures as outlined in Section 5.
Impact assessment criteria as provided by Arcus Gibb (2008), and listed in Appendix F. Note that only activities that are rated as having some impact either with or without mitigation are listed here.
All impacts are negative unless stated otherwise

Impact	Intensity	Extent	Duration	Impact on irreplaceable resources	Consequence	Probability	SIGNIFICANCE	Nature of impact	Confidence
Construction phase									
Loss or degradation of wetlands resulting from dewatering:	Medium	Low	Medium	Low	Medium	Low	**Low - Medium**	**Neg**	Med
With mitigation	Low	Low	Medium	Low	Low	Low	**Low**	**Neg**	Med
Loss or degradation of wetlands resulting from seawater contamination, following dewatering	High	Low	Medium	Medium	Medium	Low	**Low - Medium**	**Neg**	High
With mitigation	Not required								
Degradation of wetlands as a result of construction of internal access roads	Low	Low	High	Low	Low	Low	**Low**	**Neg**	Med
With mitigation	Low	Low	Low	Low	Low	Low	**Low**	**Neg**	
Operational phase									
Degradation and fragmentation of wetlands as a result of internal roads	Low	Low	High	Low	Low	Low	**Low**	**Neg**	High
With mitigation	Low	Low	High	Low	Low	Low	**Low**	**Neg**	High
Cumulative impacts									
Without mitigation	Low	Low	High	Medium	Medium	Low	**Low - Medium**	**Neg**	Med
With mitigation	Low	Low	High	Medium	Medium	Low	**Low - Medium**	**Neg**	Med

5.2.5 Monitoring and evaluation programme

Implementation of a monitoring programme that allows the efficacy of mitigation measures to be evaluated during both the construction and operational phases of the proposed NPS at the Duynefontein site is strongly recommended as an essential condition of any development approval at this site.

Monitoring and evaluation would both allow the possibility of alteration of activities, within the constraints of an already-approved and possible constructed development, such that unforeseen impacts could be addressed or where mitigation measures proved ineffectual alternative measures might be introduced. Perhaps more realistically, though, given the above constraints, monitoring and evaluation provides an opportunity for refinement of both the impact assessment and the specification of mitigation measures, for any future phases of the NPS development that may be considered at this site. Monitoring data will, if the programme is appropriately designed, highlight impacts to wetlands that have not been identified in this study, for example where the significance of surface/groundwater interactions affected by activities in this portion of the site have been underestimated. Moreover, where mitigation measures have failed, or alternatively been too intense for the impact actually experienced, their evaluation can inform the assignment of mitigation measures for future applications for NPS development at this site.

Table 5.2 outlines a monitoring programme for wetland systems at the Duynefontein site. This programme should be integrated with monitoring recommendations made by the faunal, botanical and geohydrological specialists, and the results of the monitoring programme and its implications for wetlands and other ecosystems, should be evaluated on a regular basis. It should however be noted that the monitoring programme outlined here does not focus only on the construction and operational phases of Phase 1. It is also designed to inform potential future EIA assessments of Phases 2 and/or 3, with timeous collection of appropriate data to a level that will allow adequate assessment of future impacts.

It should be noted that the monitoring programme should be implemented at least one full year before construction on the site starts, to allow comparative pre-impact data. The monitoring requirements outlined here should be subject to review both before and during implementation, to ensure that they remain up-to-date and relevant to current approaches and information about the site and its wetlands. They should be used to inform the compilation of an Environmental Management Programme, which both specifies target values for different indicators, and thresholds for intervention.

Table 5.2 Recommended wetland monitoring programme at Duynefontein

Recommended monitoring programme	Rationale	Target wetlands	Duration of monitoring	Reporting frequency	Management objectives
Collection of baseline data regarding patterns of succession of aquatic invertebrate in seasonal wetlands	No baseline data are available to indicate norms in invertebrate succession in seasonal wetlands such as these – the impact of changes in hydroperiod on these communities cannot therefore be assessed	Sw7 Sw1 and Sw2	Over one wet season, to cover period from first inundation to zero inundation.	Once-off - annual	Biodiversity maintenance – specifically, no change in wetland function / habitat quality
Monitoring of aquatic invertebrate communities	Maintenance of habitat for invertebrate fauna is a motivating factor in the assessment of the proposed NPS – yet there are limited invertebrate community data for the site	Sw7 Sw1 and Sw2	Twice yearly – as determined by first year succession monitoring (above)	Annual	Biodiversity maintenance – specifically, no change in wetland function / habitat quality
Water chemistry monitoring	Changes in wetland water chemistry might be associated with NPS development, as a result of stormwater runoff, drawdown or other impacts	Sw7 Sw1 and Sw2	Weekly in the wet season, tying in with groundwater monitoring and hydroperiod assessment, for a period of two years – at least one year prior to construction	Monthly	No change in natural variation in wetland chemistry
Monitoring of water depth and soil moisture in seasonal wetlands	Understanding the links between groundwater flows and wetland systems is crucial to assessment of wetland impacts, and to determining whether hydroperiod change has occurred as a result of an impact	Sw7 Sw1 and Sw2	Weekly in the wet season; monthly in summer	Six monthly	No change in natural seasonal hydroperiod cycles, and maintenance of natural variability
Monitoring of wetland plant zonation	Wetland plants respond to medium-term changes in nutrient availability, salinity and hydroperiod and, in conjunction with water chemistry monitoring, may provide good long-term indicators of both wetland resilience and the significance of changes in these factors for the affected wetlands	Sw7 Sw1 and Sw2	Annually	Annual	Biodiversity maintenance – specifically, no change in wetland function / habitat quality

5.3 Recommended mitigation for Bantamsklip

5.3.1 General mitigation against loss or degradation of wetlands associated with site layout

A The establishment of "no go" development areas within the site

The setting of "no development" areas on site is considered essential mitigation, and requires consideration of both surface and groundwater interactions between wetlands and development-related activities on the site.

The following restrictions on layout within the site as a whole are recommended:

i. The area north of the R43 should be managed as a no-go development area for all purposes associated with the construction and operational phases of the proposed NPS.

5.3.2 Mitigation against construction phase impacts

A Loss or degradation of wetlands as a result of dewatering

Given that the modelled dewatering scenario (Visser *et al*. 2011) indicates that dewatering activities could extend at least relatively close to wetland systems north of the R43, and given the extremely high importance of these wetland systems, the following mitigatory measures are recommended to minimise the likelihood of this impact occurring:

i. Remodelling of the radius of draw-down by the geohydrological team, once a preferred footprint has been decided on for this site, to allow fine-tuning of the dewatering approach;
ii. Inclusion, on the basis of the above, of an impermeable or semi-permeable membrane or other similar technology to limit the radius of draw-down, if necessary. This measure has been suggested by Visser *et al*. (2011) – and its implementation would be supported at this site as a precautionary measure against drawdown impacts to wetlands;
iii. Ongoing monitoring of surface/groundwater interactions on the site.

B Loss or degradation of wetlands as a result of other construction-related impacts on the site south of the R43

This impact is considered improbable and no mitigatory action is required.

C Degradation of wetlands as a result of physical disturbance to wetlands north of the R43 during construction

Given the high conservation status of the Groot Hagelkraal wetland system, the following mitigation measure is recommended with a view to impact avoidance.

- The entire site to the north of the R43 should be treated as a no-go area for all activities associated with the construction phase of the proposed NPS.

In order to ensure that the above measure occurs in practice, it is strongly recommended that:

i. The area of the site north of the R43 should be formally declared and managed as a conservation area, with no links to NPS-related activities occurring on the site to the south of the road and all activities taking place in this area being informed by the primary objectives of conservation of the important ecosystems within this area;
ii. A strategic conservation management plan should be formulated, outlining clear strategies that will enable effective conservation and management of the site, including liaison with landowners on adjacent sites in the headwaters of the Groot Hagelkraal system to the east and north east of the site;
iii. Sufficient funding should be allocated to the conservation area to allow for effective ongoing management of alien vegetation on the site in the short to medium term and for implementation of the requirements of the conservation management plan; and
iv. A Trust Fund (or equivalent approach) should be established to provide funds for the conservation of the site into the long term, and outside of the operational time frames of any proposed NPS. Appropriate ecotourism uses could be included in the long-term management of the site, provided that they are sustainable and not in conflict with the tenets of the conservation management plan.

5.3.3 Mitigation against impacts associated with the operational phase

A Abstraction of surface or groundwater to supply fresh water to the NPS

Since the use of water from the Groot Hagelkraal system and associated groundwater has specifically been excluded from the Bantamsklip fresh water supply options (Eskom 2008b), no mitigation measures are required in this regard.

B Degradation of wetlands associated with the Groot Hagelkraal system through alien encroachment and/or increased disturbance / use of the site

Implementation of the measures outlined in Section 5.3.2C(i-iv) should effectively mitigate against this impact and in fact would result in substantial long-term improvement in wetland management, potentially resulting in an improvement in PES of the more impacted wetlands downstream of the Eskom site.

C Increased fragmentation of wetlands up- and downstream of the Groot Hagelkraal system as a result of increased road use along the R43

Mitigation measures outlined here are aimed at impact reduction. The following measures are recommended, although it is noted that, since the road and the culvert fall outside of Eskom's property, the measures below cannot be made a condition of authorisation:

i. The existing wetland crossing beneath the R43 should be widened through the installation of additional box and pipe culverts, that aim to:
    - Allow ease of movement between up and downstream reaches of the wetland for both aquatic (water dwelling) and wetland associated fauna (e.g. mongooses, otters, small antelope). The size of culverts used should be specified by the faunal specialist, but it is recommended that they be located such that wetted, braided channels, their saturated margins and areas of terrestrial habitat abutting the wetland corridor are provided with up- and downstream linkages, thus establishing a functional corridor through the system as a whole.
    - Improve the spread of flow into the downstream system – the present culvert contributes to a substantial change in wetland function, resulting in constriction of flows by narrow culverts, and dramatic narrowing of the wetland swathe, when compared to the upstream reaches.

D Impacts to wetland systems associated with indirect impacts of the proposed NPS development

This aspect lies outside of the realm of this EIA assessment. The practical considerations around reduction of indirect impacts to important freshwater ecosystems as a result of development of a NPS ought however to be highlighted. The measures outlined here have been put forward with the aim of controlling the sphere in which indirect impacts can take place, and are not intended to provide specific measures regarding a range of unknown factors. They have not been included in formal impact assessment tables.

The following restrictions on the kinds of development that can be undertaken with regard to staff housing associated with the development of the NPS at Bantamsklip would be recommended, although it is understood that such development would be controlled by existing spatial development frameworks in the affected areas:

i. Development planning must ensure that the indirect effects of any influx of personnel into either new or existing, but presently seasonally occupied developments in the Pearly Bay area do not result in any of the following:
    - Discharge of additional volumes of treated effluent into the Klein or Groot Hagelkraal systems
    - The need for abstraction from surface or groundwater systems linked to the Groot Hagelkraal system

ii. Development planning should also ensure that nodal development of accommodation for the purposes of servicing the site does not occur within the presently sparsely developed area to the east of the Groot Hagelkraal system, where it would serve to increase fragmentation of the Agulhas Plain systems.

Table 5.3 Impacts to wetlands as a result of development of a nuclear power station at Bantamsklip

Impacts as described in Section 4, with assessment with mitigation based on implementation of full mitigation measures as outlined in Section 5.
Impact assessment criteria as provided by Arcus Gibb, and listed in Appendix F.
Note that only activities that are rated as having some impact either with or without mitigation are listed here
All impacts are negative unless stated otherwise

Impact	Intensity	Extent	Duration	Impact on irreplaceable resources	Consequence	Probability	SIGNIFICANCE
CONSTRUCTION PHASE							
Loss or degradation of wetlands as a result of dewatering	Medium	Low	Medium	Medium	Medium	Low	**Low - Medium**
Mitigated	Low	Low	Medium	Low	Low	Low	**Low**
Degradation of wetlands as a result of physical disturbance to wetlands north of the R43 during construction	Medium	Low	Medium	Medium	Medium	Low	**Low - Medium**
Mitigated	Low	Low	Low	Low	Low	Low	**Low**
OPERATIONAL PHASE							
Degradation of wetlands associated with the Groot Hagelkraal system through alien encroachment	Medium	Medium	Medium	Medium	Medium	Medium	**Low to Medium**
Mitigated	Low	Low	Low	Low	Low	Low	**Low**
Increased fragmentation of wetlands up- and downstream of the Groot Hagelkraal system as a result of increased road use along the R43	Low	Medium	Medium	Low	Low	Medium	**Low**
Mitigated	Low	Low	Low	Low	Low	Low	**Low**
Impacts to wetland systems associated with indirect impacts of the proposed NPS development	Low	Low	Low	Low	Low	Low	**Low**

5.3.4 Recommended monitoring and evaluation programme

Development of a NPS at the Bantamsklip site is not considered to be associated with substantial impacts to freshwater ecosystems and indeed, with mitigation, the cumulative impact of the development would be positive. Monitoring of wetland systems at this site can nevertheless be motivated for on the grounds of tracing ecological improvement through implementation of effective conservation strategies. The monitoring programme outlined in Table 5.4 is recommended, to be implemented in conjunction with botanical and faunal monitoring.

Monitoring requirements should be subject to review both before and during implementation, to ensure that they remain up-to-date and relevant to current approaches and information about the site and its wetlands. They should be used to inform the compilation of an Environmental Management Programme, which both specifies target values for different indicators, and thresholds for intervention.

Table 5.4 Recommended wetland monitoring programme at Bantamsklip

Recommended monitoring programme	Rationale	Target wetlands	Frequency and duration of monitoring	Reporting frequency	Management objectives
Use of WET-Health to monitor wetland condition and trajectory of change"	Improvement in wetland health has been predicted as a result of implementation of the management recommendations in this report. Repeat WET-Health surveys of the site allow an opportunity to track whether substantial changes in wetland condition have occurred over time	Sections GH5, GH4 and GH1	Annually	Annual	Long term improvement in WET-Health to category B
Groundwater monitoring of water table depth in the Groot Hagelkraal system adjacent to the R43	Ensuring that the modelled estimates of drawdown extent are correct, and that dewatering does not result in changes in flows through wetland systems.	the Groot Hagelkraal River system adjacent to the R43	Two-weekly or as recommended by geohydrologist	Six monthly	No change in natural seasonal hydroperiod cycles, and maintenance of natural variability

5.4 Recommended mitigation for Thyspunt

5.4.1 General mitigation against loss or degradation of wetlands associated with site layout

A The establishment of "no go" development areas within the EIA corridor

Note: recommendations include the area immediately east of the owner controlled boundary, labelled "subject to additional land being purchased" in Figure 4.5.

Even given the specification of "recommended" development areas on the Thyspunt site (Figure 4.5B), the development platform would still closely abut the western boundary of the Langefonteinvlei and the largest of the coastal seeps, while aspects of infrastructure (e.g. the eastern access road) would also pass in the close vicinity to a number of wetlands. The setting of "no development" areas on site is thus considered essential mitigation, and requires consideration of both surface and groundwater interactions between wetlands and development-related activities on the site, as outlined in Secretion 2.3.12. The following restrictions on layout within the recommended development area are recommended:

i. Establishment of sufficient setback distance from the Langefonteinvlei and the southern major hillslope seep, such that the **groundwater systems** on which these wetlands rely remain intact, and there is no change in the quality, timing or magnitude of water supply to these wetlands. This aspect needs to be determined by:
    - Detailed geohydrological modelling of the drawdown associated with the proposed site footprint – the results of such modelling are presented (in draft form) in Visser *et al*. (2011), and illustrated in Figure 4.7A and B.
    - Monitoring of seasonal fluxes in wetland saturation, inundation, flow regime and depth to groundwater, and ensuring that none of these factors change, as a result of NPS activities; and
    - Incorporation of a "safety factor" into the above through collaboration with the geohydrological team, to accommodate periodic drought-induced stresses, which would reduce the resilience of groundwater systems, such that they will no longer be able to meet ecosystems demands that are currently met quite adequately, even in times of drought – note that drought periods may become more frequent as a result of climate change (see Section 4.3.14)

ii. Establishment of adequate setbacks (see Figure 5.1) over and above those required to ensure the above requirements, to allow for **physical separation** of developed areas from conservation areas:
    - Minimum setbacks of **200m from the western edge of the Langefonteinvlei** and at least **150m from upstream edge of each coastal seep** are recommended. These setbacks are wider than those generally recommended in South Africa, and take cognisance of the following factors:
        a. the wetland buffers need to:
            - protect the wetlands from noise and physical disturbance, which could reduce their value as habitats and feeding areas for medium to large fauna which both contribute to biodiversity in these habitats and also may contribute to the long term maintenance of habitat patchiness within wetlands such as the Langefonteinvlei, by the creation of paths through dense wetland vegetation and through turnover of wetland

soils during digging / rooting activities (e.g. porcupine and bush pig activities) - Semlitsch and Bodie (2003) showed that core wetlands need to be edged by terrestrial habitat of up to 290 m in width if their purpose is to sustain key amphibian and reptile life-history functions (clearly such buffers depend on the actual species in question);

- allow adequate space for dissipation of runoff from hardened areas – buffer areas > 20m may be adequate for such functions (Castelle et al 2002), depending on the kinds of flows envisaged, soil type, slope and vegetation type. In the present case, the soils are sandy and would promote rapid infiltration;
- provide a buffer for the protection of wetlands from invasion by weedy and other alien and/or invasive plant species, emanating from disturbed areas, roadsides, lawns and pathways associated with the developed portions of the site – the spread of alien grasses (e.g. kikuyu grass (*Pennisetum clandestinum*) is regarded as particularly undesirable in wetland areas; and
- provide adequate corridors for movement of terrestrial and wetland associated fauna between the coast and the Oyster Bay dunefield, which incorporate these wetland areas. The recommendations made in the faunal report for the Nuclear 1 EIA should provide guidance in this regard – corridors in the order of at least 200m width are often required for such purposes

b. the wetlands are presently relatively unimpacted and thus potentially associated with a high level of sensitivity to new impacts;
c. in the case of the coastal seeps, the downstream extent of the wetlands will be lost with climate-change induced sea level rise, and an upland expansion is likely; and
d. the wetlands have a high conservation importance, are unlikely to be represented elsewhere at the size represented by the Langefonteinvlei (northern and southern sections) and are thus considered irreplaceable.

iii. Conservation of dunes that are considered to act as critical support areas for the coastal seep and hillslope seep wetlands:

a. no development should extend beyond the southern toe of the high dune that forms the southern boundary of the hillslope seep immediately south of the Langefonteinvlei. Existing developments in this area might remain, provided that there is no change to their existing footprints (e.g. the construction of parking bays, expansion of built structures); and
b. the low dune immediately north of the largest coastal seep wetland (* in Figure 2.6) should be protected from construction activities.

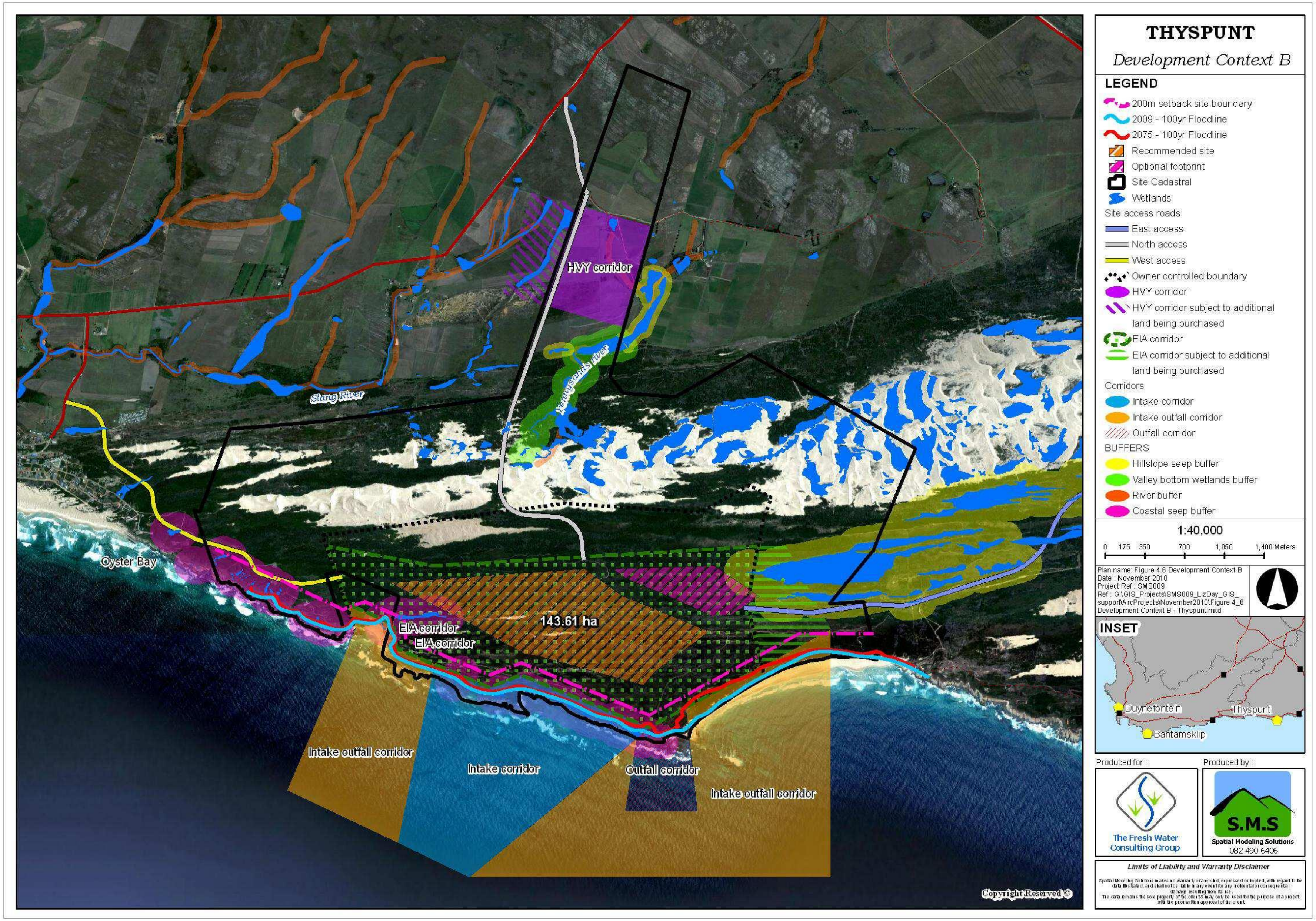


Figure 5.1 Proposed development corridors, "recommended" development site and proposed infrastructure in the context of wetlands mapped at the Thyspunt site, showing recommended setback areas from different wetland types. Buffers as recommended in Section 5. 4.1.

B The establishment of "no go" development areas within the HV corridor

The following recommendations (illustrated in Figure 5.1) should be taken into account when planning the layout of proposed structures within the HV Yard:

i. No hardened surfaces or infilling should take place within 100m of the edge of the Pennysands depression or within 50m of the edge of the Pennysands hillslope seep, which lies on the erf just east of the panhandle (Figure 4.5). These recommendations take cognisance of the following:
   - the depression probably receives some subsurface through-flows from the (presently agricultural) area immediately to its north;
   - the depressional wetland is only moderately impacted and would be vulnerable to edge impacts associated with the development of a hardened surface on the HV yard; and
   - the hillslope seep is an important hydrological link feeding the Pennysands system and has moreover retained important natural elements (e.g. indigenous wetland vegetation).

ii. No hardened surfaces or infilling should take place within 30m on either side of the degraded, channelised hillslope seeps shown in Figure 4.5B to the west of the panhandle. This recommendation takes cognisance of the following:
   - the degraded condition of the hillslope seeps in this area;
   - the vulnerability of the seeps to further erosion as a result of increased runoff and concentration of flow; and
   - the fact that the seeps contribute to the hydrology of wetland flats and depressions just north of the Oyster Bay dunefield edge.

iii. Formal delineation of the edge of the Pennysands depression and the hillslope seep leading to the depression should take place, using the methodology outlined in DWAF (2005) to provide more detail to the final design and layout of this portion of the site.

Implementation of **all of the above (A and B)** recommendations is considered essential mitigation and would contribute to reducing many of the impacts to wetlands that would be associated even with the "preferred" development footprints. Figure 5.1 shows that, to achieve such setbacks, the development footprint would need to be pulled back from the western edge of the northerly portion of the Langefonteinvlei, as well as from the northern edge of the larger coastal seep,

The implications of implementing the described setbacks are assessed in Table 5.5 in terms of several individual and cumulative impacts accruing to different wetlands on and associated with the site

It is noted that the above restrictions may have implications for the possibility of accommodating the proposed volumes of spoil on the site. The recommendations made in this report should be read in conjunction with those of other biophysical specialists in this regard, to determine the total "no development" area.

5.4.2 Mitigation against construction phase impacts

A Loss or degradation of duneslack depressions and/or hillslope seep wetlands (e.g. Langefonteinvlei) as a result of dewatering

Recommendations made in this section have taken a precautionary approach in setting mitigation measures, in the light of the following issues:

- the importance of the Langefonteinvlei, of which the northern and eastern portions are linked to the water table;
- the importance of the duneslack depressions, which are believed to be fed by a combination of surface and groundwater;
- the proximity of the edge of the modelled radius of drawdown to the downstream end of the Langefonteinvlei (Figure 4.7A);
- the severe negative ecological and biodiversity consequences that would be associated with the loss or degradation of these systems if groundwater draw-down is associated with dewatering; and
- the uncertainty associated with the present model, in so far as it is not based on an accurate size and/or location of NPS footprint, and may thus not accurately reflect the extent of draw-down.

On the basis of current levels of understanding of wetland / groundwater interactions and wetland function, the following measures are recommended:

- Provision in the design of the NPS for the use of a cutoff wall or other design with similar function, to limit the radius and depth of drawdown from the surrounding area during both the construction and operational phases of the development. Figure 4.7B shows the extent of the modelled draw-down from this site, assuming the inclusion of a partial cut-off wall in draw-down design. The figure has been extracted directly from Visser *et al*. (2011)'s updated model, which was based on a year of detailed surface / groundwater monitoring at the site. This figure indicates no impacts to any wetlands, other than the coastal seeps that would be impacted through diversion of groundwater flows.
- The proposed drawdown mitigation design should meet the following design criteria as a minimum:
    i. The extent of drawdown should not extend beneath the Langefonteinvlei (that is, there should be no change in groundwater levels at any point of the Langefonteinvlei, as a result of groundwater draw-down. This measure is conservative, as data indicate that only the northern and eastern portions of the Langefonteinvlei are directly linked to the groundwater table (Visser *et al*. 2011);
    ii. There should be no change in natural fluctuations of water table height in the transverse dune system (this impact is considered unlikely);
    iii. The cutoff wall should extend around all sides of the drawdown area, to limit the extent of impacts to coastal seep wetlands;
    iv. If necessary, more than one cutoff wall (or other similarly functioning system) should be utilised, to control the extent of dewatering required across the NPS site as a whole (e.g. dewatering of construction areas where groundwater may be exposed by site levelling, even though construction to bedrock as in the case of the Nuclear Island is not required;
    v. The short-term drawdown effects and dune instability that would occur during installation of the proposed cutoff wall/ membrane / other appropriate device would need to be such that they too did not result in any drawdown of the Langefonteinvlei and its associated wetlands or the duneslack wetlands in the mobile dune; and

vi. the specifications outlined in Section 5.4.2B (below) for mitigation against dewatering-related loss of coastal seep wetlands should be met in the design.

- The detailed design of the proposed drawdown mitigation measure should be fine-tuned on the basis of the results of longer term surface and groundwater monitoring, being carried out at the Thyspunt site
- Installation of the membrane (or other appropriate structure (e.g. as outlined in Eskom 2009) would need to be one of the first construction-phase activities, to reduce the extent of draw-down during construction.

B Loss or degradation of coastal seep wetlands as a result of interference with surface or groundwater flows during construction

Coastal seep wetlands would definitely be lost through the construction of a NPS on the Thyspunt site. The proposed siting of the NPS footprint in the area just north east of the western edge of Thyspunt beach means that the site closely abuts the portion of the site associated with the broadest band of coastal seep wetlands (Figure 2.6).

The coastal seep wetlands are considered of high importance – although they are repeated along the coast outside of the site, they are seldom in as unimpacted and extensive a form as on the Thyspunt site, where moreover they contribute to wider biodiversity at a landscape level (Section 2.3).

The following measures (which have already largely been specified as mitigation in Section 5.4.2A) are thus recommended as essential, in order to reduce the extent and intensity of impacts to these wetlands:

i. The recommended cutoff wall/ semipermeable membrane / other appropriate structure (see Section 5.4.2A) should be extended to pass around the entire NPS construction area, to reduce the extent of draw-down;
ii. The proposed membrane / alternative structure would also need to facilitate the controlled passage of water to downstream coastal seeps, by allowing drainage of water through the cobble layer downstream of the NPS structure and cutoff walls; detailed mitigation design would need to show clearly how this could be achieved;
iii. Given the risk of seawater intrusion during dewatering, and the fact that the impacts of seawater intrusion on wetland soils may be long-lasting, measures should be in place during construction to ensure that groundwater in the cobble layer is not interrupted even on a short term basis. Thus a system should be in place throughout the construction and operational phases of the development to facilitate the spread of dewatered or diverted flows from the terrace area, back into the lower levels (i.e. the cobble layer) of the aquifer;
iv. The approach taken should ensure that the downstream passage of groundwater along the cobble layer of the Algoa aquifer is not interrupted south of the terrace, by the NPS excavation to bedrock or by the shallower NPS terrace excavation. This means that provision should be made for the re-introduction and spread of diverted or dewatered groundwater flows into the cobble bed layer downstream of the excavation, such that the coastal seeps are neither starved of fresh water, nor exposed to concentrated flows that result in erosion of shallow surface soils at areas where discharge occurs.

    In this regard, drilling of recharge wells downstream of the dewatered area has been suggested (SRK 2009). Eskom (2009) proposes a system that makes use of a semi-permeable slurry wall, constructed between the NPS terrace and the Langefonteinvlei with its associated southern hillslope seep, to control the extent of surface dewatering beyond the terrace, and to allow rapid passage of surface water to the cobble layer of the aquifer within the NPS terrace, through the use of a series of recharge wells. The proposed system includes a permanent impermeable barrier around the deeper NPS excavation, which would be drawn down to bedrock during excavation, but would be maintained at about 2mamsl after construction, to facilitate drainage of groundwater into the intake basin and avoid upwelling of salt water into groundwater outside of the terrace area (Eskom 2009).Previous versions of this EIA (e.g. Day 2008) have suggested the use of a rock-filled recharge basin in the form of a longitudinal channel that runs the east-west length of the site, thus facilitating the spread of flows into the downstream seeps.

Whatever approach is taken should demonstrate in its detailed design how the multiple requirements of achieving groundwater recharge, lateral spread of groundwater flows and management of saltwater intrusion both now and as sea levels rise, can be achieved (see below). Detailed design should include input by a team comprising the project design engineers, specialist geohydrologists and wetland ecologists.

Assuming successful implementation of the above measures, the mitigated outcome for coastal seep wetlands would be as follows:

- There would be unavoidable degradation of coastal seeps immediately adjacent to the NPS site – but the number of these wetlands would be limited;
- The outfall corridor from the NPS would result in destruction of coastal seep wetlands in this area; and
- Coastal seep wetlands to the west would be progressively less impacted, and there should be some retention of freshwater pools that occur along the rocky shores west of the Thyspunt

These impacts are assessed as of <u>at least medium negative significance</u>.

C Degradation of coastal seep wetlands as a result of receipt of concentrated volumes of potentially sediment-rich water from dewatered areas

The following mitigation measures are recommended, with the objective of reducing these impacts:

i. Implementation of the recommended development setbacks (Section 5.4.1A) should take place to distance wetlands from the sources of impact;
ii. Sediment settlement ponds should be provided for water pumped from the excavation site during construction. The location of such ponds should be decided on in collaboration with the botanical and wetland specialists;
iii. "Cleaned" water from sediment settlement areas should be passed back into the aquifer recharge system, as discussed in Section 5.4.2B – important components of the recharge system include the need for adequate redistribution of flows downstream of any groundwater diversion structures;
iv. Adequate space should be left between the coastal seeps and the edge of the NPS terrace to allow for re-distribution of groundwater in the lower section of the aquifer – the coastal setback of 200m recommended by other biophysical specialists (e.g. Harrison et al. 2009) should probably be regarded as a minimum setback. Input from the geohydrological specialists is required in this regard.
v. Provision should also be made for adequate maintenance of the functions of sediment settlement ponds.

D Degradation of the western extent of the Langefonteinvlei and other non-coastal hillslope seep wetlands as a result of the proximal location of spoil areas

The following mitigation measures are recommended, with the objective of reducing this impact:

i. Spoil areas must be managed from the outset such that opportunities for wind and water caused erosion of spoil are negligible;
ii. The "no go" areas outlined in Section 5.4.1A should be respected in determining spoil and topsoil locations
iii. No areas outside of the recommended development areas, pulled back as specified in Section 5.4.1A to allow the establishment of adequate buffers, should be considered for the dumping of spoil, without specific comment from a wetland specialist regarding their implications for wetland ecosystems.

E Degradation of coastal seepage wetlands and/or the Langefonteinvlei and other non-coastal hillslope seep wetlands as a result of catchment hardening and runoff from laydown areas

The following mitigation measures are recommended, with the objective of reducing this impact:

i. A detailed stormwater management plan must be developed and implemented to allow for the responsible management of runoff from laydown areas and the construction site as a whole. Implementation of the management plan should achieve the following objectives:
    - No change in the quality of water passing off the laydown area – that is, salinity, pH, suspended sediments, nutrient, heavy metal and hydrocarbon concentrations or values should all approximate background concentrations for surface and/or groundwater runoff in this portion of the site. This means that the laydown areas should include areas such as treatment wetlands for the management of runoff; and
    - Runoff from laydown areas should be managed such that it can dissipate into the area downstream of the site, without resulting in the formation of any channels or erosion areas as a result of concentration of flows. The natural flow of water through the site area is by infiltration into the sands, and little if any water is channelled across the site on the surface. An east-west running infiltration channel has been proposed in Section 5.4.2D – this could be used to manage infiltration and dispersal of uncontaminated surface runoff too.

F Degradation / drainage / infilling of hillslope seeps and valley bottom wetlands north of the Oyster Bay dunefield

The following mitigation measures are recommended, with the objective of both reducing and rectifying identified impacts:

i. The recommendations outlined in Section 5.4.1B, regarding setbacks from wetlands in this area should be implemented.
ii. All wetlands and setback areas outlined above should be managed as "no go" areas during construction and fenced off with wire mesh fencing before contractors move onto site.
iii. A detailed stormwater management plan should be developed and implemented to allow for the responsible management of runoff from all hardened surfaces set in place in this portion of the site. The management plan should achieve the following objectives:

- No change in the quality of water passing off hardened surfaces – that is, salinity, pH, suspended sediments, nutrient, heavy metal and hydrocarbon concentrations or values should all approximate background concentrations for runoff / surface groundwater in this portion of the site
- Runoff from hardened surfaces should be managed such that it does not result in concentration of flow into hillside seeps or valley bottom wetlands.

iv. Any road crossings of wetlands should make adequate provision in their design to ensure that narrowing of wetlands and concentration of flow does not occur – such design should include the use of multiple culverts and / or pipe drains set at multiple intervals across all such crossings, to allow both surface flows and subsurface seepage through the system.
v. Effective control measures must be implemented on stockpile areas to prevent wind or water erosion of loose material into water courses and wetlands.
vi. Provision must be made on site for adequate numbers of conveniently located toilet facilities, to reduce the likelihood of the use of natural vegetation by construction workers for these purposes.
vii. Allowance should be made for the rehabilitation of any wetland areas that are damaged in this area during construction – a wetland ecologist should specify required remedial and /or rehabilitation activities.

5.4.3 Mitigation against operational phase impacts associated with the NPS

A Loss or degradation of coastal seep wetlands as a result of interference with surface or groundwater flows

Mitigation measures outlined in Sections 5.4.2 (B and C) that centre on the objectives that should be met in the design of a dewatering and aquifer re-charge system at the NPS should be seen as applicable for addressing the operational phase impact of ongoing degradation of the coastal seeps

Note however that despite mitigation, the residual impact of the operational phase on the coastal seeps is considered of <u>high negative significance</u> – the affected seeps are unlikely to revert to their pre-impact condition.

B Salinisation of coastal seeps as a result of seepage of return-coolant

This impact is not considered likely and mitigation measures are not recommended.

•

C Degradation of remnant coastal seepage wetlands as a result of catchment hardening / receipt of stormwater runoff

The following mitigation measures have been recommended with a view to reducing these impacts:

i. The ecological buffers / setbacks recommended in Section 5.4.1A should be implemented for the coastal seeps;
ii. A detailed stormwater management plan must be developed and implemented to allow for the responsible management of runoff from all hardened surfaces on the NPS site. It is noted that the existing plans indicate separation of contaminated and uncontaminated runoff from the site;
iii. Implementation of the management plan should achieve the following objectives:

- No change in the quality of water passing off the laydown area – that is, salinity, pH, suspended sediments, nutrient, heavy metal and hydrocarbon concentrations or values should all approximate background concentrations for surface runoff / groundwater in this portion of the site. This means that the laydown areas should include areas such as treatment wetlands for the management of runoff;
- Runoff should be managed such that it can dissipate into the area downstream of the site, without resulting in the formation of any channels or other erosion areas as a result of concentration of flows. The natural flow of water across the site at present is by infiltration into the sands, and little if any water is channelled across the site on the surface. To achieve this, uncontaminated runoff should be passed into the recharge system designed as part of mitigation measures against dewatering, as outlined in Sections 5.4.2B and C.

D Degradation of hillslope seeps and valley bottom wetlands north of the high dunefields

Mitigation of the identified impacts would be achieved by:

i. Full implementation of the recommendations outlined in Section 5.4.1B, regarding setbacks from wetlands in this area;
ii. Management of all wetlands and setback areas outlined in Section 5.4.1B as "no go" areas during construction - these areas should be fenced off with wire mesh fencing before contractors move onto site;
iii. Development of a detailed stormwater management plan for this area to allow for the responsible management of runoff from all hardened surfaces set in place in this portion of the site. The management plan should achieve the following:
    - No change in the quality of water passing off hardened surfaces – that is, salinity, pH, suspended sediments, nutrient, heavy metal and hydrocarbon concentrations or values should all approximate background concentrations for runoff / surface groundwater in this portion of the site; and
    - Runoff from hardened surfaces should be managed such that it does not result in concentration of flow into hillside seeps or valley bottom wetlands.
iv. Formulation and implementation of an operation-phase management plan for this area, which addresses in detail the long term operation and maintenance of stormwater management structures, including detention areas and water quality management wetlands.

E Degradation of dune slack wetlands as a result of increased vehicle passage across the dunes

Although avoidance of this impact is sought by implementation of the following measure, it is considered unlikely that absolute adherence will occur over the operational life time of the plant:

- The mobile dunes should be managed as a no-go area to all vehicles, including quad-bikes, and with the exception of specified activities identified in an Operational Phase Management Plan for the site and carried out for the purposes of alien-clearing and/or conservation management.

5.4.4 Mitigation against impacts associated with sewage management

Treatment of sewage on site

The following mitigation measures have been compiled with a view to avoidance of impacts to the Langefonteinvlei and other wetlands:

i. The proposed sewage plant should be south and at least 500m west of the Langefonteinvlei, noting that groundwater is believed to flow in a south / south easterly direction (SRK 2009 and Visser *et al*. 2010).
ii. No possibility of infiltration or overflow to link treated or untreated sewage with surface or groundwater flows should be allowed – *inter alia*, ponds used in the facility would need to be adequately lined.
iii. The option of disposing of treated effluent in an evaporation pond should ideally not be pursued, as this unduly enlarges the disturbance footprint of the site. Instead, it is recommended that the sewage treatment plant be designed such that full recycling of effluent is possible within the plant.

5.4.5 Mitigation against impacts associated with different alternatives for fresh water supply on the site

Mitigation measures applicable to each of the four freshwater supply options are outlined below. As in Section 5.4.5, these mitigation measures have been formulated with a view to reducing impacts at a local level (at the level of the NPS site itself) and avoiding impacts to wetlands associated with the site as a whole and its associated wetland systems.

Option A Abstraction from the Thyspunt aquifers

Given the importance of the wetland systems potentially affected and the risk of incurring drawdown as a result of construction and operational phase impacts associated with dewatering, avoidance mitigation is strongly recommended in this case, as follows:

- Option D (desalination), along with the use of treated effluent as outlined in Section 5.4.5 (Option C) should be pursued as the least-damaging option, in terms of wetland ecosystems.
- Short-term abstraction could be considered during the construction phase, provided that abstraction occurred downstream of all receiving wetland systems, and/or from flowpaths that would not be expected to contribute to coastal seep function.

Option B Piping municipal water from the St. Francis Bay feeder line

Again, avoidance mitigation is recommended – there are no positive aspects associated with this option (from a wetland ecosystem perspective) and considerable negative impacts. Thus:

- Option D (desalination), along with the use of treated effluent as outlined in Section 5.4.5 (Option C), should be pursued as the least-damaging option, in terms of wetland ecosystems.
- Short-term abstraction (up to six months) could be considered during the construction phase, provided that abstraction occurred downstream of all receiving wetland systems, and/or from flowpaths that would not be expected to contribute to coastal seep function.

Option C Piping water from the Orange River scheme

As with Options B and A, avoidance mitigation is again recommended – there are no positive aspects associated with this option (from a wetland ecosystem perspective) and considerable negative impacts. Thus:

- Option D (desalination), along with the use of treated effluent as outlined in Section 5.4.5 (Option C), should be pursued as the least-damaging option, in terms of wetland ecosystems.
- Short-term abstraction (up to six months) could be considered during the construction phase, provided that abstraction occurred downstream of all receiving wetland systems, and/or from flowpaths that would not be expected to contribute to coastal seep function.

Option D Desalination

No impact mitigation is necessary from a freshwater perspective in terms of this option, although mitigation in terms of the recommended sewage management option would have implications for desalination – namely, that desalinated water should be supplemented by treated sewage effluent, to minimise waste and improve sustainable resource use and management (see Section 5.4.5).

5.4.6 Mitigation against the impacts of different options for linking transmission lines from the NPS to the HV yard

Of the three assessed options, the use of so-called "special" structures, capable of spanning the full mobile dune area would be clearly preferred, as this would in theory effectively avoid the impacts of both the maintenance road and the pylon structures within the dunefield. However, this option has been declared unfeasible by the Eskom technical team (comments at the 3rd EIA Specialist Integration Meeting of November 2009), and is not assessed further in this report.

Neither of the two remaining options (use of conventional transmission towers and lines, or the use of dual circuit transmission lines and associated towers) would allow impact avoidance. The following mitigation measures are recommended, in the event that the NPS development at Thyspunt is approved:

i. The dual circuit transmission line system is the preferred option from an ecological perspective, as it would be associated with fewer structures in the mobile dune than the conventional system, albeit with a shorter span. However, comments from Eskom Project Management indicate that this option would not be feasible from a safety perspective and from a perspective of guaranteeing supply;
ii. Pylon structures should be located outside of any wetland areas and such that they do not affect surface or subsurface flows – the geohydrological team and a wetland specialist should be approached with regard to finalising the footprints for these structures, before any final design for the system is approved;
iii. The number of structures within the mobile dune area must be minimised;
iv. No permanent maintenance tracks or roads should be allowed to run beneath the transmission lines, and **access for periodic maintenance or repair should be by air, rather than across the dunes themselves** by any vehicle in excess of a 4x4 quadbike- this should be a prerequisite for the operational management programme for the site;.
v. The foundings for the tower / pylon structures must be such that they do not impede or otherwise alter the flow of water through the dunes and/or the associated wetlands, and should not result in puncturing of any aquitards in the dune area – the geohydrological team should be consulted in this regard;
vi. Outside of the dune areas, multiple wetland areas occur, and the transmission line design should allow the following:
    a. the transmission lines must be aligned such that no towers themselves are constructed any closer than 30m from the demarcated edge of any wetland;
    b. the alignment must either
        i. allow full construction and maintenance from a helicopter, rather than using vehicles

        OR

        ii. the alignment must be such that construction and/or maintenance vehicles do not have to pass through or across any wetland area, including the Pennysands depression and the Pennysands River / valley bottom wetland. This measure is only likely to be achieved if the transmission lines are routed across the western end of the panhandle.
vii. the proposed alignment of the transmission lines from the southern edge of the mobile dunes through to their endpoint north of the Oyster Bay dunefield should be pegged out on the ground, and walked by the design engineer, accompanied by the dune geomorphologist, vegetation and wetland specialists, so that minor changes in alignment can be made, where necessary, to minimise biophysical impacts.

5.4.7 Options for the removal of sand spoil from the NPS site

Mitigation measures to address the impacts associated with options for removal of excess sand are outlined below, with the objective of avoidance of impacts to the mobile dune system and to other wetland systems. As stated in Section 4.4.7, the preferred mitigation from a freshwater ecosystems perspective would be the disposal of spoil at sea; this assessment ignores impacts to marine ecosystems that might be triggered by such activities.

Conveyance of sand across the mobile sand dunes to the northern portion of the site, using a temporary conveyor belt

The most significant impacts associated with this option are linked to the assumed need for an access road for maintenance purposes along the conveyor belt (Illenberger 2009). Within the mobile dune, Illenberger (2009) does not consider that the temporary conveyor belt will cause any damage to mobile dunes, and by implication therefore, to the dynamics of duneslack wetlands within the mobile dune system. However, the vegetated wetlands along the northern edge of the dunefield are considered by FCG to be vulnerable to impacts associated with the proposed activity.

The following mitigation measures are considered essential from a wetland perspective, should a conveyor belt system be used between the power station site and the HV Yard:

i. Sand transported in the conveyor system must be covered, to reduce accumulation of wind-blown sand in vegetated wetlands.
ii. Within the mobile dunes, the conveyer system should be routed across the least steep slopes, on the eastern portion of the transmission line corridor between the northern panhandle and the proposed NPS site, but should swing westward within the mobile dune, so as to miss the extensive wetlands on the northern portion of the dunefield in this area.
iii. North of the mobile dune field, the conveyor belt should be routed along the western edge of the panhandle, and should be such that it avoids the mapped wetland areas
iv. The proposed route for the conveyor belt should be pegged out on the ground, and walked by the design engineer, accompanied by the dune geomorphologist, vegetation and wetland specialists, so that minor changes in alignment can be made, where necessary, to minimise biophysical impacts.
v. No access road should accompany the conveyor belt – all maintenance access should be undertaken on an *ad hoc* basis by quad bike (this assumes that this approach is feasible – if a formal access road is required, then the approach is considered unmitigable.
vi. The conveyor belt should be removed in its entirety, no longer than two years after the start of its construction, and within six months of completion of sand removal, whichever is the shorter.
vii. Disturbed wetland and dune areas should be rehabilitated where necessary after the construction process.
viii. Laying the conveyor belt should be used as an opportunity to clear a substantial swathe of alien vegetation from the valley bottom wetlands.

5.4.8 Mitigation against impacts associated with different access road alternatives

Three roads have been proposed, namely

- the eastern access road
- the western access road and
- the northern access road.

Of these, it is FCG's understanding that two access roads would be required by Eskom, with the western and northern access roads being perceived by Eskom as alternatives, particularly during the construction phase.

Mitigation specifications have been divided into generic measures that are applicable to the construction and operational phases of any road, and are based mainly on best practice impact reduction, and specific measures that are applicable to particular road alternatives.

A General construction phase impact mitigation – all routes

Note that mitigation measures outlined in this section are based on the information provided to specialists during the assessment phase of this report, which indicated that the final road width for all of the options is likely to be based on a single lane road, of width (including curbing) up to 22m (Email of K. Neethling, Arcus GIBB to specialists: 7 October 2009). Subsequent input from Eskom Project Management (comments on February 2011 version of this report) suggest that in some cases a 60 – 100 m wide disturbance corridor may be necessary to accommodate cut and fill. It should be noted that such a disturbance corridor has **not** been assessed in this report, and deviations from the assessed 22m corridor may change both the significance ratings and the recommended mitigation measures outlined in this report. Such deviations would require formal re-assessment and comment, if required to be included in the assessed road design. **Please refer to Appendix E31 of the EIR report for an updated assessment regarding the access roads to the Thyspunt site.**

The mitigation measures outlined here all aim at reducing the identified construction-phase impacts of wetland degradation associated with receipt of contaminated runoff from construction areas. They are applicable to all routes.

i. The setbacks from wetlands outlined in Section 5.4.1A should be implemented with regard to the siting of all road construction materials, including stock-piles. Methods Statements by the contractor should specify methods to reduce wind and water erosion from stock piles into adjacent wetlands
ii. Construction camps and areas for overnight vehicle storage should be agreed on in collaboration with the specialist botanist and a wetland specialist, and should be located outside of any wetlands or drainage lines
iii. The Environmental Management Programme (EMP) should specify Best Practice methods to be followed during construction to minimise pollution opportunities in the site camps, including methods such as the use of bunding around overnight parking and refuelling areas
iv. Where the proposed road passes over or alongside wetlands (areas specified in Section 4.4.9) a disturbance corridor of no more than 10m on either side of the road must be adhered to – the disturbance edge should be controlled by the erection of a temporary mesh fence that demarcates this corridor 11m on either side of the road (the additional 1m on either side being to allow construction activities up to the 10m edge, without restrictions by a fence line). The areas outside of the disturbance corridor should be treated as "no go" development areas; and
v. Wetland areas that are disturbed during road construction should be rehabilitated to the specifications of a wetland specialist.

It should be noted that the details of the construction process itself still need to be supplied for assessment and design of mitigation measures – aspects such as details of borrow pits, storage areas and site camps are all important parts of an EIA for a major road construction through sensitive areas and need to be addressed.

B General operational phase mitigation

The mitigation measures outlined here aim at reducing general operational-phase impacts (i.e. changes in the quality of runoff, changes in runoff velocities and disruption of faunal corridors along wetlands / river systems). Recommended mitigation measures include:

i. Construction of shallow, unlined vegetated swales along road edges, to minimise concentration of flows off road surfaces and into drainage corridors by allowing infiltration and dispersal of flows as well as water quality amelioration
ii. Installation of pipelines and /or box culverts at all points where the road crosses natural drainage lines, to prevent diversion of flows from natural systems and concentration of flows into others. The size, number and location of pipes / culverts should be determined during the detailed design phase, involving on-site collaboration with the wetland and faunal specialists, to ensure that issues such as faunal movement are addressed in an appropriate manner. Pipes / culverts should be installed such that they allow both shallow subsurface and surface flows across the road. Downstream discharge points should be equipped with erosion-control devices where necessary – note that the area is however characteristically sandy, and erosion is not expected to be a major issue.

C Mitigation against specific impacts associated with construction of the western access road

This road (mapped in Figures 3.3, 4.5B and 4.6) would entail the following activities at the specified locations:

- Crossing through the minor *Phragmites australis* hillside seep, west of W in Figure 4.6
- Disruption of flows and infilling of coastal seeps along the coastal road, as described in Section 4.4.9A2.

In addition to the mitigation measures outlined in Sections 5.4.9A and B, the following measures have been recommended to mitigate against the impacts associated with this particular access route alternative:

i. *Mitigation against disruption of flows and infilling of portions of coastal seeps along the coastal road.*

Given the extent to which these seeps are likely to be impacted in the eastern portion of the site, as a result of the proposed NPS, mitigation against additional impacts to remaining relatively unimpacted wetlands with high biodiversity and conservation value has the objective of impact avoidance. This can be achieved by implementation of the following mitigation activities:

a. Re-alignment of access road further north: Ideally, the alignment should be with the existing untarred road through the site. This road runs well north of the coastal seeps and would not impact on their integrity. Its use would moreover limit the extent of disturbance through the coastal forest. However, if the existing road alignment is indeed used within the site, it would need to be a minor road, not suitable for passage by heavy vehicles. For this reason it is assumed that the least-impacting upgrading of the existing road is not feasible. Thus mitigation measures should:
   - Minimise the disturbance width associated with the proposed new road
   - Avoid the upper reaches of hillslope seeps within the site by shifting northwards
   - Avoid crossing over hillslope seep A (Figure 4.6) by shifting the alignment north
   - Allow rehabilitation of the existing access road through the site from the east to reduce fragmentation

b. Bridging the major hillslope seep B (Figure 4.6) – a bridge should be constructed over this seep, such that no interference with seepage down the dune slope occurs – this means that the span of the bridge should extend across the entire hillslope seep, and at least on either side of the seep

    - The bridge should be high enough such that light beneath the bridge is not impeded to a level where plant growth is affected
    - The design of the bridge should be informed by formal delineation of the wetland edge at the proposed bridge crossing, based on DWAF (2005)
    - Any wetland disturbance resulting from construction should be rehabilitated as soon as the bridge has been constructed
    - The wetland outside of the bridge footprint plus a defined minimum disturbance area must be treated as a no-go area during construction
c. Bridging or avoidance of wetland depression C, north of the Oyster Bay dunefield.

D Mitigation against specific impacts associated with construction of the eastern access road

Along with the generic impacts outlined in Section 5.4.9A and B, this road (mapped in Figures 3.3, 4.5B and 4.6) would also be associated with infilling of the following wetlands:

- A portion of the Eastern Valley Bottom Wetlands at X (Figure 4.6) – the proposed crossing point would pass over the last section of this wetland that is still relatively intact in terms of its geomorphology
- Portions of the minor hillslope seeps in the vicinity of Y (Figure 4.6)
- The broad swathe of braided valley bottom wetland, densely invaded by alien vegetation, between Y and Z (Figure 4.6). The proposed road alignment would not follow any existing road footprint, and would thus result in fragmentation of an extent of valley bottom wetland that presently passes uninterrupted as far as the road crossing at X.
- The road would also pass in close proximity to the southern major hillslope seep adjacent to the Langefonteinvlei, potentially increasing disturbance in the vicinity of this system

In addition to the mitigation measures outlined in Sections 5.4.9A and B, the following measures have been recommended to mitigate against the impacts associated with this particular access route alternative:

i. *Mitigation against infilling and disruption of flows at the point X (Figure 4.6), upstream of the Links golf course*

Mitigation measures recommended here are aimed at impact reduction, and comprise the following measures:

a. ideally, the road should be shifted east to the existing dirt road over the wetland, at the boundary fence between The Dunes and The Links.
    - If re-alignment takes place, bridging of the wetland areas cannot be justified, given the near-complete disruption in wetland habitat further downstream, and the road design should make use of multiple wide box culverts instead, which extend across the full width of each of the wetland “braids” or low points
    - gabions should be used to stabilise the toe of the road, thus reducing the width of infill required
b. if the road is not shifted east, but remains in the proposed alignment through this section, then bridging of the wetlands should take place, to reduce the effect of multiple wetland fragmentation
c. Management of floods into downstream areas should be designed such that retention of major floods (e.g. 1:50 year flood) takes place over a maximum period of 12 hours. This should allow reduction of flood peaks, thus protecting downstream landowners from flood damage, without resulting in retention of flows long enough

upstream to promote changes in plant communities (e.g. a shift to a *Typha capensis* dominated, permanently saturated to inundated system).

ii Mitigation against impacts associated with crossing the Eastern Valley Bottom Wetland, between Y and Z (Figure 4.6)

The valley bottom wetlands affected by this section of the road are presently impacted only by alien vegetation, and their flow is uninterrupted by artificial structures. Given their high rehabilitation potential and importance as part of a unique dune slack valley bottom system, mitigation measures aim at a high level of impact reduction if not avoidance. The following measures are thus recommended:

a. The valley bottom wetland areas should be bridged by the proposed road, rather than infilled, to prevent impacts to flow and to maintain ecological connectivity along the valley bottom system. This means that the road would need to span across three separate valley bottoms, separated by low dunes. Each span should extend from dune to dune, with bridge piers constructed on the dune ridges
b. No built structure should extend into the valley bottoms themselves
c. Alien vegetation should be cleared from the valley bottom wetland within a 100m long swathe across each system in the area crossed by the bridge
d. Disturbed areas within the wetland should be rehabilitated after construction has been completed
e. In addition, where the new road would curve westwards and run along the seaward side of the main dune ridge, efforts should be made to re-divert existing flows in the vicinity of the point W, back into the hillside seep feeding the Langefonteinvlei (south) wetlands. This measure would entail reshaping and stabilisation of the dune, where it has been cut into by the existing dirt track in this portion of the site.
f. The western portion of the road, that passes immediately south of the high dune adjacent to the Langefonteinvlei / southern hillslope seep wetland, should be shifted south, and closer to (and preferably onto) the existing dirt road alignment through this section of the site.

iii Mitigation against impacts associated with infilling portions of the minor hillslope seeps in the vicinity of Y (Figure 4.6)

Avoidance mitigation is not feasible in this case and mitigation measures take the form of minimising impacts to the wetlands, through the following:

a. Minimising the disturbance footprint
b. Pegging out the route alignment and walking it with the road design engineer, accompanied by the botanical and wetland specialists to make minor adjustments to alignment and so reduce the extent of wetlands impacted.

E Mitigation against specific impacts associated with construction of the northern road

The northern access road would entail infilling duneslack depressions within and immediately north of the Oyster Bay dunefield.

It would also provide permanent fragmentation of the Oyster Bay dunefield in an area which is currently intact, and be associated with localised disturbance in the form of changes in surface and shallow subsurface flows along the road edge.

Two forms of mitigation measures have been outlined here, with the first seeking impact avoidance and the second simply reducing the anticipated impacts of the road. Given the importance of the mobile dune system with its interconnected dune slack wetlands, and its present largely unimpacted condition, impact avoidance is the preferred mitigation measure from a wetland perspective.

1 Mitigation approach: Impact avoidance

This measure entails treating the crossing of the dune systems as a "no go" alternative, and selecting the western road alignment (with mitigation) as the preferred alternative

2 Mitigation approach: Impact reduction

Note that impact reduction is not the preferred approach to this alignment.

In the event that the northern access route is approved, the following measures are recommended:

i. The road should be regarded as a temporary access road only, for the duration of the construction phase, and its extent between the existing site access road on the southern edge of the Oyster Bay dunefield, and the northern edge of the Pennysands depression, must be removed completely, along with all construction material, from the site within one year of the end of construction. Note however that in terms of Eskom's proposed timeline for the project (Nuclear1 typical construction program.xls; Eskom – 2009) even this approach would mean that the road would be in place for a period of 10 years

ii. Illenberger (2009)'s "smooth road" design is the preferred option in this scenario, given that construction of a bridge across the dunes would in any case apparently require construction of an access road across the dunes

iii. The alignment of the road should be such that the number of duneslack wetlands crossed by the road within the mobile dunes is minimised

iv. Where the road passes over the depressional wetlands and wetland flats along the northern edge of the wetlands, multiple culverts should be used in close succession, such that surface and subsurface movement of water within and between depressional wetlands is not impeded. The size of culverts should be decided on in conjunction with the faunal and wetland specialists, to ensure that culverts are adequately sized to allow the safe movement of both wetland and wetland-associated fauna beneath the road.

5.4.9 Mitigation against cumulative impacts of the construction and operational phases of the NPS and its associated activities addressed in this report

Even with implementation of the least-impacting mitigation measures outlined in this section for each impact, the cumulative impact of the proposed development at the Thyspunt site remains high, accompanied by net loss of biodiversity (coastal seep wetlands), and degradation or risk of degradation to the remaining systems – in particular, the duneslack depressions within and immediately north of the Oyster Bay dunefield. Even where the assessment of individual impacts, with mitigation, results in medium to low levels of significance, the net result of all of these activities is likely to be a substantial erosion of the integrity of what is at present a natural ecosystem of extremely high conservation importance – not least because it has to date avoided the large-scale fragmentation of the mobile dune system that is associated with the proposed Nuclear1 development, with its transmission lines, roads and other infrastructure that would pass directly through the mobile dunes.

<u>The cumulative effect of the impacts addressed in this section are, even with mitigation measures, thus still considered to be of overall high negative significance </u>(Table 5.5).

Mitigation against cumulative residual impacts cannot feasibly aim for impact avoidance, other than through the no-development alternative (itself not considered a favourable alternative – see Section 6.1.4) and it must be assumed that the recommended mitigation measures for each impact have aimed at impact reduction or avoidance wherever possible. The only feasible mitigation left that might address cumulative impacts to the system as a whole is that of provision of a so-called "compensation offset" (Section 5.1) to offset site-specific impacts. These revolve around the management of the erven to the east of the Thyspunt site.

Given that the routing of the eastern access road would be through a number of additional erven not included in the present site, it is assumed that either servitude rights or the land itself would need to be purchased by Eskom along the entire route to the east of the present site, as far as the St. Francis Bay road, and to the west of the site, if the western access road is approved. On the east of the site, the erven through which the road would pass include a substantial portion of the Oyster Bay dunefield, almost to its eastern extent, and the Eastern Valley Bottom Wetland, as far as The Links. Several of these erven have development rights either in place or under application, including the approved housing development on Erf R/745. They are thus considered likely to be linked, at present, to certain degradation of wetland areas.

The following compensatory measures are recommended as essential measures to offset the cumulative impacts that would be associated with development of a nuclear facility at Thyspunt:

i. The entire Thyspunt site, outside of the specified footprints for the NPS and the HV yard should be legally declared and managed as a formal conservation area, with all activities taking place in this area informed by the primary objectives of conservation of the unique ecosystems within this area
ii. In addition:
    a. All erven through which the proposed road would cross to the east of the present Thyspunt site boundary as far as the impacted Links boundary should be incorporated into the managed Nature Reserve proposed for the Thyspunt site itself, as outlined in Section 5.4.3A. This means that the entire extent of Eastern Valley Bottom Wetlands would be secured for conservation, as well as substantial portions of the mobile dune system - these erven would need to be purchased by Eskom (see Figure 5.2). It is recognised that securing such erven is not necessarily possible – and <u>in this case, mitigation will not be possible, thus affecting the overall significance of the development with respect to its implications for wetland systems</u>.
    b. The southern, smaller mobile dune system and its associated dune slack wetlands should also be included in the conservation area - that is, erven 8/746; 5/746, 179/745 and 12/746
    c. Existing development rights on these erven should be ceded, and formal conservation status for the site should be sought, along with the Thyspunt site conservation area
    d. All activities taking place in this extended area should be informed by the primary objectives of conservation of the unique ecosystems that occur there.
    e. A strategic conservation management plan should be formulated, outlining clear strategies that will enable effective conservation and management of the area
    f. Sufficient funding should be allocated to the conservation area to allow for effective management of alien vegetation on the site in the short to medium term and for implementation of the requirements of the conservation management plan
    g. A Trust Fund (or equivalent approach) should be established to provide funds for the conservation of the extended conservation area into the long term, and outside of the operational time frames of any proposed NPS
    h. Current initiatives by local conservation groups within the Cape St. Francis and Francis Bay community to declare the greater Sand River and associated wetlands and terrestrial areas as a declared Ramsar site should be pursued, and an application to this end should be submitted to the relevant decision making bodies.

If the considerable conservation opportunities entailed by implementation of the offset mitigation measures recommended above could be realised, and assuming full implementation of all other mitigation measures recommended in this report, then the assessed cumulative impact of the proposed NPS development would change, to one that is considered of overall positive impact. It would allow:

- Protection of the Langefonteinvlei;
- Conservation of some but not all of the coastal seep areas;
- Conservation of most of the Oyster Bay dunefield, with its associated wetlands, as far as The Links golf course;
- Conservation of the Eastern Valley Bottom wetlands as far as The Links golf course; and
- Active management of all of the above areas, in terms of a legal commitment to effect alien vegetation removal on an ongoing basis.

Areas of uncertainty regarding the realisation of the above include:

- The need for detailed engineering design to confirm that mitigation measures against drawdown impacts can be effectively implemented;
- The need for resolution regarding disposal options for sediment (in this regard it must be noted that, based on the results of the oceanographic and marine assessments, the EIR has concluded that marine disposal of spoil is the preferred option);
- The availability for purchase of proposed “offset mitigation” land to the east of the site;
- The need for confirmation that allowance will be made for other costly mitigation measures, such as the use of helicopters for routing pylon maintenance in dune areas; the costs of alien removal and the costs of management of land purchased to the east of the present site, for conservation purposes.

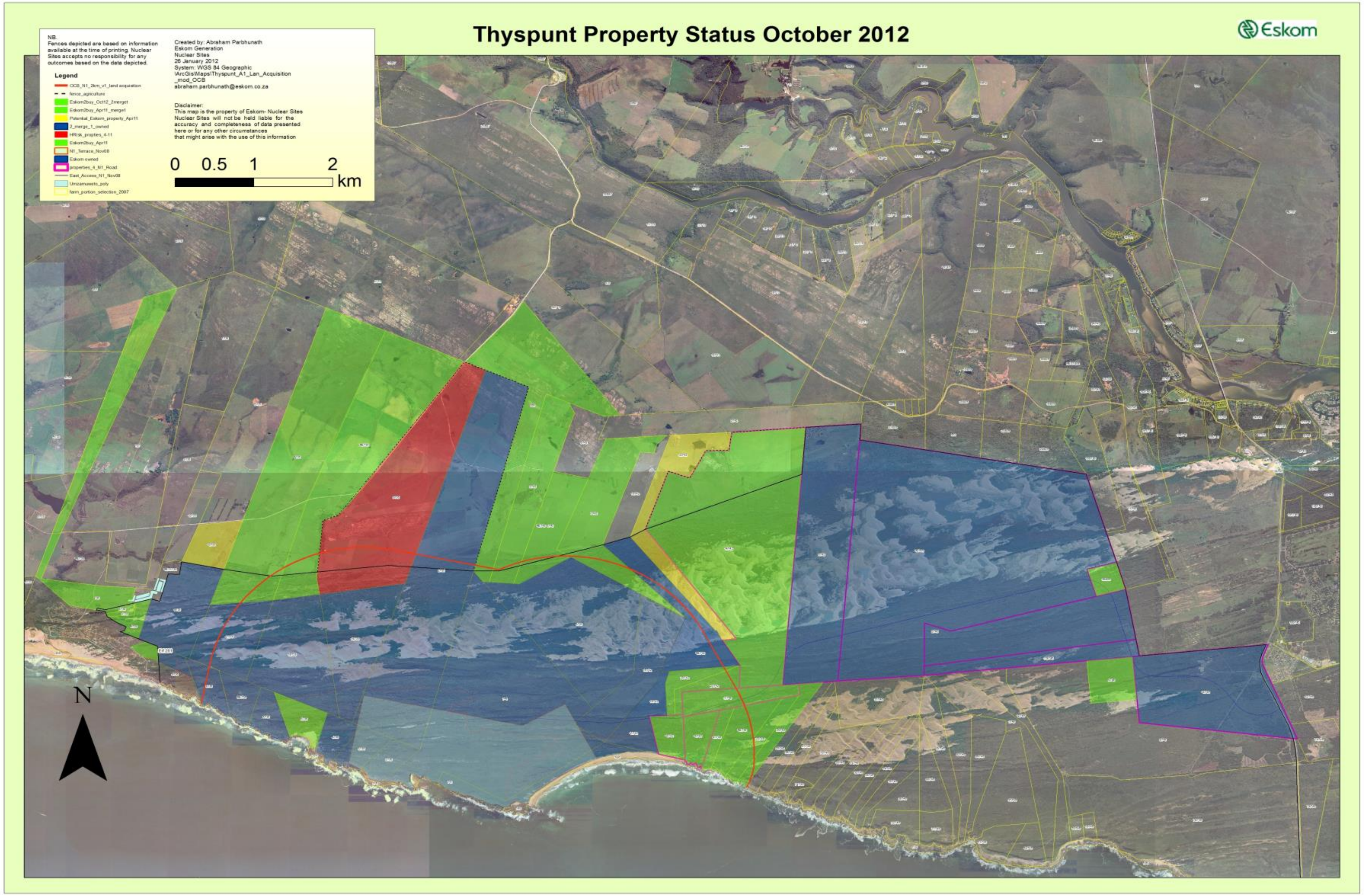


Figure 5.2 **Aerial photograph showing erven on and adjacent to the Eskom site assessed in this report.** This indicates the areas recommended for incorporation into the Eskom conservation area (all shaded properties), in the event that the application is authorised at Thyspunt.

Table 5.5 Assessment of impacts to wetlands as a result of development of a nuclear power station.
Impacts associated with development of a nuclear power station on the Thyspunt site
Impacts as described in Section 4, with assessment with mitigation based on implementation of full mitigation measures as outlined in Section 5.
Impact assessment criteria as provided by Arcus Gibb, and listed in Appendix F
Note that only activities that are rated as having some impact either with or without mitigation are listed here

Impact	Intensity	Extent	Duration	Impact on irreplaceable resources	Consequence	Probability	SIGNIFICANCE	Confidence	Status
CONSTRUCTION PHASE									
Loss or degradation of the Langefonteinvlei and/or duneslack wetlands as a result of dewatering	High	Low	Medium	High	High	Low	**Medium**	Very low	Neg
With mitigation	Medium	Low	Medium	High	Medium	Low	**Low - Medium**	Very low	neg
Loss or degradation of coastal seep wetlands as a result of interference with surface or groundwater flows, including dewatering activities	High	Low	High	High	High	High	**High**	High	Neg
With mitigation	High	low	high	Medium	Medium	Medium	**Medium**	low	neg
Degradation of coastal seep wetlands as a result of receipt of concentrated volumes of potentially sediment-rich water from dewatered areas	Medium	Low	Medium	High	Medium	Medium	**Medium**	Low	Neg
With mitigation	Low	Low	Medium	High	Medium	Low	**Low - Medium**	Low	neg
Degradation of the Langefonteinvlei (western sector) and other non-coastal hillslope seep wetlands as a result of the proximal location of stockpiles of spoil or topsoil	Low	Low	Medium	High	Medium	Low	**Low - Medium**	Low	Neg
With mitigation	Low	Low	Medium	Low	Low	Low	**Low**	High	Neg
Degradation of coastal seep wetlands as a result of catchment hardening and runoff from laydown areas	Low	Low	Medium	High	Medium	Medium	**Medium**	Medium	Neg
With mitigation	Low	Low	Medium	High	Medium	Low	**Low – Medium**	Medium	Neg
Degradation / drainage / infilling of hillslope seeps and valley bottom wetlands north of the high dune fields	High	Low	High	Medium	Medium	High	**Medium**	Medium	Neg
With mitigation	Low	Low	High	Medium	Medium	Low	**Low**	Medium	neg

Impact	Intensity	Extent	Duration	Impact on irreplaceable resources	Consequence	Probability	SIGNIFICANCE	Confidence	Status
OPERATIONAL PHASE									
Loss or degradation of coastal seep wetlands as a result of interference with surface or groundwater flows	High	Low	High	High	High	High	**High**	Medium	Neg
With mitigation	Medium	Low	High	High	Medium	High	**Medium**	Medium	Neg
Degradation of remnant coastal seepage wetlands as a result of receipt of stormwater runoff	Low	Low	High	High	Medium	Low	**Low - Medium**	Low	Neg
With mitigation	Low	Low	Low	Low	Low	Low	**Low**		
Degradation of hillslope seeps and valley bottom wetlands north of the high dune fields	Low	Low	High	Low	Low	High	**Low - Medium**	Low	Neg
With mitigation	Low	Low	High	Low	Low	Low	**Low**	Medium	Neg
Degradation of dune slack wetlands as a result of increased vehicle passage across the dunes	Medium	Low	High	High	Medium	Medium	**Medium**	Low	Neg
With mitigation	Low	Low	Low	Low	Low	Low	**Low**		
Conservation of remaining dune slack, coastal seep and valley bottom wetlands on the site	Medium	Low	High	High	Medium	Medium	**Medium**	Medium	**Pos**
With mitigation	Low	Low	Low	Low	Low	Low	**Low**		
Impacts associated with sewage management options at Thyspunt									
Treatment of sewage on site: water quality impacts to wetlands	Medium	Low	High	Medium	Medium	High	**Medium**	low	Neg
With mitigation	Low	Low	High	Medium	Medium	Low	**Low - Medium**	Medium	neg
Impacts associated with different alternatives for fresh water supply									

Impact	Intensity	Extent	Duration	Impact on irreplaceable resources	Consequence	Probability	SIGNIFICANCE	Confidence	Status
Alternatives 1 to 3: degradation of wetlands along pipeline routes or as a result of abstraction	Medium	Low	High	Low	Medium	Medium	**Medium**	low	neg
With mitigation	Avoidance mitigation						**Low**		
Impacts associated with different options for linking transmission lines from the NPS to the proposed HV yard									
Wetland disturbance, fragmentation and disruption of through-flows as a result of access roads and transmission towers in or across wetlands: both options	Medium	Low	High	High	Medium	High	**Medium**	Medium	Neg
With mitigation (i.e. mitigated use of dual circuit transmission system)	Medium	Low	High	High	Medium	Low	**Low - Medium**	Medium	Neg
Impacts associated with removal of sand spoil from the NPS site									
Conveyance of sand to the panhandle using a temporary conveyor belt: degradation of duneslack wetlands, as well as depressions and valley bottoms north of the mobile dune field	High	Low	Low	High	High	High	**High**	Medium	Neg
With mitigation	Medium	Low	Low	High	Medium	Medium	**Medium**	Medium	Neg
Impacts associated with different access road alternatives									
All routes: Construction phase: wetland degradation as a result of disturbance, water quality changes, compaction	Medium	Medium	Medium	Medium	Medium	High	**Medium**	Medium	Neg
With mitigation	Low	Medium	Low	Medium	Low	Medium	**Low**	Medium	Neg

Impact	Intensity	Extent	Duration	Impact on irreplaceable resources	Consequence	Probability	SIGNIFICANCE	Confidence	Status
All routes: Operational phase: wetland fragmentation; disruption of faunal and hydrological corridors; degradation of wetlands as a result of water quality impacts and erosion; infilling and constriction of wetlands at bridge crossings	Medium	Medium	High	Medium	Medium	High	**Medium**	Medium	Neg
With mitigation	Low	Medium	High	Medium	Medium	Low	**Low - Medium**	Medium	Neg
Eastern route: disturbance of the eastern valley bottom wetland at crossing point; localised impacts to flow	Medium	Medium	High	Medium	Medium	High	**Medium**	Medium	Neg
With mitigation	Low	Medium	High	Medium	Medium	Low	**Low - Medium**	Medium	Neg
Western Route: infilling of coastal and hillslope seep wetlands and disruption of through-flows	Medium	Medium	High	Medium	Medium	High	**Medium**	Medium	Neg
With mitigation	Low	Medium	High	Medium	Medium	Low	**Low - Medium**	Medium	Neg
Northern Route: infilling of a number of duneslack depressions; fragmentation of the dune system; potential disruption of through-flows	High	Low	High	High	High	Medium	**Medium - High**	Medium	Neg
With mitigation	High	Low	High	High	High	Medium	**Medium - High**	low	Neg

Impact	Intensity	Extent	Duration	Impact on irreplaceable resources	Consequence	Probability	SIGNIFICANCE	Confidence	Status
CUMULATIVE DEVELOPMENT IMPACTS									
Unmitigated impact of development	High	Medium	High	High	High	High	**High**	Low	neg
Cumulative impacts associated with development, without incorporation of offset mitigation, but with all other mitigation in place	Medium	Medium	High	High	Medium	High	**Medium**	low	neg

5.4.10 Recommended monitoring and evaluation programme

Table 5.6 outlines a monitoring programme for implementation at the Thyspunt site. Monitoring here includes both baseline hydroperiod monitoring and monitoring in the event that construction at this site is approved.

Monitoring requirements should be subject to review both before and during implementation, to ensure that they remain up-to-date and relevant to current approaches and information about the site and its wetlands. They should be used to inform the compilation of an Environmental Management Programme, which both specifies target values for different indicators, and thresholds for intervention.

Table 5.6 Recommended wetland monitoring programme at Thyspunt

Recommended monitoring programme	Rationale	Target wetlands	Frequency and duration of monitoring	Reporting frequency	Management objectives
Monitoring of water depth / depth to water table and soil moisture in key wetlands over time	This will set a pre-construction baseline and allow identification of impacts after construction and establish with high certainty the extent of groundwater dependency of the different wetlands	Langefonteinvlei and southern counterpart– monitoring points should be located upstream and downstream of the wetlands Selected dune slack wetlands in the mobile (Oyster Bay) dunes Selected depressional wetlands immediately north of the Oyster Bay dunefield Selected coastal seep wetlands	Recommend that well points / boreholes make allowance for installation of a water level recording device, to allow collection of data at more frequent intervals than allowed by physical site visits. Soil moisture monitoring devices are also recommended in Visser et al (2011). Data should be collected over at least one full year before dewatering plans are finalised. Ongoing, until at least the end of the first three years of operational phase.	Annual (baseline) Monthly (construction phase)	No change in wetland hydroperiod with drawdown; no change in wetland soil moisture regime
Monitoring of water quality – major nutrients; EC	This will allow identification of impacts associated with contaminated seepage from various activities associated with the NPS site, including stormwater runoff	• Key coastal seep wetlands in vicinity of site and control wetlands further away; • Langefonteinvlei • Selected valley bottom wetlands in Slang River catchment	Monthly baseline data collection over at least one year Weekly data collection during construction phase Monthly data collection for first three years of operational phase	Annual (baseline) Monthly (construction phase)	No change in natural water quality fluctuations
Plant zonation	Mapping of plant zonation at selected wetland sites should allow tracking of changes in wetland function associated with diversion of flows, and allow measurement of the efficacy of groundwater infiltration and dispersion mitigation measures Monitoring of climate change	Control and potentially affected coastal seeps	Annual - ongoing for first five years of operational phase (due to assumed slow response rate).	Annual	No change in wetland zonation or shrinkage / expansion of wetland edge

	impacts will also be enabled				
Monitoring of selected radioactive isotopes in coastal seeps and Langefonteinvlei – surface water and selected plant tissue	There are no background data for radioactive isotopes for this site, against which to gauge possible future contamination.	Langefonteinvlei and selected coastal seeps	Two-monthly for one year (baseline) – annual after five years of operational phase	Annual	No change over time from baseline conditions

6 SUMMARY OF IMPACTS WITH AND WITHOUT MITIGATION

This section describes the “no development” scenarios applicable to each site. These form the backdrop against which formal assessment of each identified impact takes place. Such formal assessments, which examine the impacts of different aspects of the development both with and without mitigation measures being in place, are outlined in Tables 5.1, 5.3 and 5.5, based on information / discussions outlined in Sections 4 and 5.

6.1 Description of the no-go alternative

6.1.1 General

Arcus GIBB (2008) specifies that the “no development” alternative is not a feasible outcome for this EIA as a whole, given the need for power at a national level and South Africa’s strategic decision to pursue nuclear technology in meeting its power requirements, Nevertheless, at the level of individual sites, this alternative has been considered, and it is not assumed that NPS development will take place at each of the sites.

6.1.2 Duynefontein site

The “no development” alternative at this site would see the site still being managed as a nuclear power facility for the Koeberg NPS.

6.1.3 Bantamsklip site

Rapid expansion of development along this section of coast would probably result in the expansion, over time, of resort type development within the site, if NPS development was no longer an option. Development options for the site including its associated wetlands, would be restricted by existing legislation and potentially subject to the outcome of an EIA. Future management by the South African National Parks Board of the portion of the site north of the R43 is also a possible future scenario, and would afford similar conservation opportunities to those that would be enabled by the development of a NPS on the southern portion of the site.

6.1.4 Thyspunt site

Resort development is expanding rapidly in the non-Eskom owned areas between Oyster Bay and Cape St. Francis, with many erven having subdivision or development rights either approved or planned. The “no development” alternative at the Thyspunt site would probably result in ongoing low-levels of ribbon development along the coast and abutting the dunes, valley bottom and dune slack wetlands, and gradual formalisation of existing roads through and along the dune areas. The incorporation of the entire dune system into a managed conservancy with Ramsar status is a possibility, assuming support from all landowners and funding to secure adequate management of the area, which is a prerequisite for the declaration of Ramsar status. However, to date this option has not achieved success, and the problems associated with managing a conservation area with multiple landowners are likely to be considerable. At least low-level development across all erven would probably form part of the no-go alternative, and would be accompanied by “edge effects” into the mobile dune system, and likely degradation to wetlands such as the Langefonteinvlei of at least moderate levels, over time. The kind of fragmentation of the mobile dune that has been linked in this study to potential road and pylon construction across the dune is also likely in a no-development scenario, with landowners crossing the dune on an *ad hoc* basis, as is the case at present. Considerable resources would need to be allocated for conservation purposes, in order to reduce and control alien vegetation across the area. Such alien clearing, although not carried out effectively to date on many of these erven, is a legal obligation of any landowner in terms of the Conservation of Agricultural Resources Act (CARA).

Incorporation of the site into a coastal cluster of the Baviaanskloof megareserve is also currently being considered. In this scenario, management of the site would fall under the auspices of the Eastern Cape Parks Board.

None of the "no development" options for the Thyspunt site appear to allow for incorporation of dune or wetlands outside of the current Eskom NPS site into conservation areas, and it is assumed that, if development of a NPS did not take place, development in and around these systems would continue, with existing development rights being renewed or implemented.

With this being said, however, it is fully acknowledged that ideally, none of the wetlands within and associated with the Oyster Bay dunefield should form part of any development offset. In the event that a no development alternative was available that provided adequate funding opportunities for alien control, and did not include piecemeal fragmentation of the area into multiple small developments, then a no-go alternative would clearly be preferred (from an ecological perspective) to any development of a nuclear power facility at this site.

6.2 Summary of the outcomes of the impact assessments at each site

6.2.1 Duynefontein

The formal assessment of impacts associated with the development of a NPS at Duynefontein (Table 5.1) indicates that the proposed development is unlikely to result in any unmitigable impacts to wetland systems that would have high negative significance. Moreover, the recommended mitigation measures are not considered onerous, and revolve largely around best practice measures and excluding specified wetland areas from development.

While development of the proposed NPS at the Duynefontein site would not be associated with any impacts of high negative significance, assuming implementation of mitigation measures, it must be noted that it does not present positive opportunities for conservation either, unlike the other two sites. Conservation of natural ecosystems has already been achieved through the past formation and management of the Koeberg Nature Reserve, the integrity of which is threatened by, rather than secured by, the proposed NPS development.

6.2.2 Bantamsklip

Development of the proposed NPS at Bantamsklip would not be associated with any impacts to wetland systems that are considered unmitigable or that would, once mitigated, result in a negative impact of higher than "low" significance level (Table 5.3). This is because the NPS-associated activities would be concentrated in the area to the south of the R43. The impacts that have been assessed revolve around indirect impacts to the ecologically important Groot Hagelkraal wetlands, primarily associated with increased traffic through the area (e.g. affecting the use of the wetlands as a corridor between high lying areas, the estuary and the sea). Other impacts that have been identified include those associated with increased development in the presently small resort settlement of Pearly Beach, and the increase in sewage treatment and water demands, with their potential knock-on effects for wetland systems. Low confidence is attached to this assessment, given the low certainty that the impact could occur.

Mild concerns raised by the geohydrological EIA (SRK 2009) as well as by Visser *et al.* (2011) regarding the extent of draw-down effects on the wetlands of the Groot Hagelkraal and Koks Rivers have been addressed through recommendations for accurate groundwater modelling, based on final proposed NPS platforms and design, and the potential need (to be informed by the above) for implementation of a membrane or other device that will severely limit draw-down extent.

The recommended mitigation measures for the development at this site are not considered complex. Moreover, the possibilities to bring about positive impacts to wetland ecosystems through implementation of recommended mitigation activities have been assessed as of high positive significance, and thus of bearing in the decision making process for this site. It should be noted however that the actual achievement of these positive outcomes relies on a concerted effort to secure the Groot Hagelkraal wetlands, including their extensive hillslope seeps and adjacent terrestrial areas, and to put in place measures that will assure their management and conservation in the long term. The proposed NPS site is believed to be one of the most feasible vehicles for setting in place such management, based on the observed conservation management at the Duynefontein site, and visible present efforts at both the Thyspunt and Bantamsklip sites in terms of the control of alien vegetation.

6.2.3 Thyspunt

The length and detail of the assessment tables for the proposed NPS development at Thyspunt (Table 5.5) highlight the complexity of the potential impacts to wetland systems at this site. Most of the potential impacts are associated with a high level of negative significance in their unmitigated form. In some cases, this high rating is the result of uncertainty regarding present levels of understanding of system level drivers and responses, particularly with respect to the mobile dune system. This lack of certainty has led to a highly conservative approach to the assessment of any activity that could potentially impact on dune function. Mitigation measures against such proposals have thus taken the approach of impact avoidance, through the pursuit of other options.

The most significant sources of impact to wetland systems are associated with interferences in surface / groundwater interactions in the vicinity of the site, particularly during construction associated draw-down. Potential means for reducing draw-down impacts to the Langefonteinvlei do however appear to be available, and the confidence in their efficacy has been increased by the results of the first year of detailed wetland / groundwater monitoring at the site, as reported by Visser *et al.* (2011). The feasibility of such measures has not however been tested, and it should be noted that mitigation against the identified drawdown effects requires that a high level of confidence should be attached to the efficacy of mitigation.

Impacts (outright loss and degradation) to a section of near-pristine coastal seep wetland are not however considered effectively mitigable, and this impact remains of high negative significance.

The assessment process summarised in Table 5.5 also indicated ecologically preferred alternatives for a range of activities that would be associated with the proposed NPS. The outcomes of the assessments are as follows:

- Preferred sewage treatment alternative: on-site treatment;

- Preferred fresh water supply option: desalination, supplemented by treated effluent; with short term construction phase abstraction of groundwater only, subject to a range of conditions; and
- Disposal of sand on portions of the panhandle, provided that the mitigation measures outlined in this report (use of a covered system; no roads) are considered technically feasible.

Other activities, such as the proposed routing of transmission lines across the mobile dunefields and wetland areas to the north, coupled with possible transport of sand across the dunefield, would result at best in a general degradation of what is at present a relatively undisturbed, one-in-a-kind habitat, and at worst, threaten the function and structure of the dune system which is a critical support system for the wetlands.

The assessment of different alignments for the access roads, as shown in Table 5.5, brings into play another set of complicating issues. The assessment process indicates that the proposed eastern access, with substantial mitigation measures focusing on avoidance of critical impacts, would be the preferred access option. If two access routes are required, specifically for construction, then the proposed western access route is greatly preferred to the northern route.

The eastern route carries with it a means to mitigating against the high cumulative significance of the proposed development. On the basis of full and effective implementation of all recommended mitigation measures, including recommendations around access routes to the site, the active conservation management in the long term (beyond the life time of the NPS site) of the Eskom site, and the recommendation for application to be made for the Oyster Bay dunefield and its associated dune and wetland systems to be managed as a Ramsar wetland area, and on the assumption that Eskom will purchase all erven through which the proposed access road passes, and include this land in the conservation area, then the cumulative impact of the development would be <u>assessed as of positive significance in</u> terms of wetland systems. This implies that the inclusion of the full extent of remnant valley bottom wetland between Langefonteinvlei and The Links golf course, and the inclusion of a substantial portion of the Oyster Bay dunefield system in this effective reserve, outweighs the definite impact of loss of and degradation to a section of presently unimpacted coastal seep wetland, of high conservation importance.

<u>The following factors / assumptions would be critical in assuring the validity of this difficult assessment</u>:

- The geohydrological model informing the assessment of the extent of groundwater drawdown is accurate (high confidence is attached to this model);
- The final siting of the NPS is such that it minimises loss of and degradation to coastal seeps;
- The mitigation measures outlined in the report are technically achievable, tested and will meet their specified objectives of further limiting drawdown;
- No further NPS phases are considered for this site;
- Conservation management of the extended site occurs; and
- The purchase of relevant erven takes place with near-immediate effect, before approved, planned or proposed development of erven adjacent to the valley bottom wetlands and dunes takes place.

This last point is of crucial significance – once development along the valley bottom wetlands has occurred, then the positive impacts associated with the proposed access road are largely nullified, and the cumulative impact of the development on wetland systems would be assessed to be of high negative significance. Unfortunately, this also means that Eskom is dependent for mitigation on a measure that reflects the willingness of adjacent landowners to sell their land.

7 CONCLUSIONS

All of the site alternatives include in their boundaries and immediate surroundings wetland systems that are of high ecological importance, relatively unimpacted and considered to be either among the last (in the case of Duynefontein) remnants of particular wetland habitats that have been lost from large areas or, in the case of the Bantamsklip and particularly the Thyspunt sites, they are considered unique systems that are unlikely to be represented in their present form, extent and complexity anywhere else in the world. Their conservation status is extremely high and any threats to their integrity have been assessed as of high negative significance.

Of the three site alternatives, development of a NPS at the Duynefontein site would be associated with the lowest level of negative impact to wetland systems, and all identified impacts would be mitigable. The reason for the low rating of significance at this site lies mainly in the fact that both the EIA and the HV corridors for the proposed plant lie well away from the most sensitive wetlands on the site – that is, the duneslack depressional wetlands in the south western portion of the site. Groundwater modelling associates a low level of draw-down risk to both these and other natural wetlands on the site. In terms of other aspects of the proposed NPS development at the site, avoidance mitigation of the remaining wetlands on the site is considered feasible, and recommendations have been made to this end, recommending that the dune area and northern wetlands are left intact.

Development of a NPS at Bantamsklip would potentially be associated with a few impacts, all of which are linked to activities indirectly resulting from the proposed NPS development. These include expansion of urban development in the nearby settlement of Pearly Beach (note that assessment of this aspect was not included in the scope of this report), further fragmentation of wetland corridors as a result of increased traffic to the site and potentially increased traffic over the northern section of the site. The most important form of mitigation against the last two impacts centres on securing the long-term conservation and management of the Groot Hagelkraal wetlands on the northern sector of the site, by a combination of declaring this sector a nature reserve, to be managed from an ecosystem conservation perspective, and setting aside sufficient funds to ensure its management beyond the life span of the NPS. Note that the latter point is essential – failure to assure the conservation of the site in the future means that short-term impacts that have been off-set against long term conservation benefits are not in fact mitigated. However, if the required conservation approach can be set in place, then development of a NPS at the Bantamsklip site would in fact be beneficial to wetland ecosystems, and the development of the site would thus be associated with a significant positive impact. This report has noted however the difficulty entailed in uncoupling of the assessment of impacts associated with the NPS development from those associated with the routing of transmission lines from the sites. The positive impact rating accorded in this study to construction of the NPS must in reality be tempered by an awareness that it may also be associated with significant negative impacts, which may not be offset by the positive opportunities entailed in conservation and management of the wetlands in the northern portion of the site.

Assessment of the impacts of the proposed NPS development at the Thyspunt site has been the most difficult part of this EIA. The site includes portions of wetlands of extremely high conservation status, which are considered part of a one-of-a-kind system. Any impacts that threaten the interconnected functions or present ecological state of the duneslack wetlands, the permanently vegetated hillslope seeps that include the Langefonteinvlei, the parallel valley bottom wetlands or the coastal seep systems is considered of high negative significance. However, at the same time it is recognised that the "no-development" alternative at this site is unlikely to result in effective conservation of the system. Existing approvals for developments that closely abut or, in the case of The Links golf course development, have already encroached right across, valley bottom wetlands, constitute permanent impacts or future threats to the functioning and long-term integrity of the wetland systems. In the absence of development of a nuclear power site, there is no reason to expect that similar developments would not be approved elsewhere in the system, resulting in ongoing erosion of ecological integrity.

Nevertheless, the loss of portions of the coastal seeps at Thyspunt would be an impact that is of high negative significance, and only partially mitigable. Degradation of substantial areas of the seeps is a certain outcome of development of a NPS at this site, although the extent of degradation is considered mitigable to some extent, with the eastern location of the plant contributing to a reduction in the extent of affected coastal seep wetlands. However, such a location does mean that the proposed NPS would lie relatively close to the critically important Langefonteinvlei, although the recommended cut-off wall for groundwater would prevent impacts on the wetland.

Of the two potentially affected wetland types (the coastal seeps and the permanently vegetated hillslope seeps south of the Oyster Bay dunefield that comprise the Langefonteinvlei), the latter have a higher conservation priority, owing to the low likelihood of other wetlands of similar size, structure, condition and function occurring outside of the present study area. The greatest threat to the Langefonteinvlei wetland as a result of the proposed NPS would be that potentially associated with draw-down of groundwater from the wetland, as a result of dewatering of the NPS footprint. The numerical modelling carried out on surface/ groundwater interactions at the site (Visser *et al.* 2011), which included modelling of various draw-down scenarios, indicates that it is unlikely that there will be any impact to these wetlands as a result of draw-down from the power station excavation, and virtually no possibility of impact if effective draw-down reduction mitigation measures can be implemented. This is largely because of the fact that 2010 monitoring data indicate that only the northern and eastern portions of the Langefonteinvlei are connected to the groundwater table, with the western and southern portions being perched, on a thick layer of organic material. Ongoing collection of surface and groundwater data from the site is expected to reinforce this finding.

Successful implementation of these and other recommended mitigation measures would considerably reduce the significance of the impacts of an NPS at Thyspunt. If the proposed mitigation measures are implemented and include the securing of extensive areas of the Oyster Bay dunefield, with its associated duneslack depressional wetlands, along with the Eastern valley bottom wetlands, then the impacts to the coastal seep wetlands, while of high significance, would in fact be offset when the cumulative impacts associated with the development are considered.

In addition to impacts associated with the NPS construction itself, the proposed project at Thyspunt would also entail the construction of extensive infrastructure across the site, including transmission lines and roads. Passage of both these forms of infrastructure across the mobile Oyster Bay dunefield has been proposed. This report considers that crossing the dunes and the associated duneslack wetlands, particularly those along the northern side of the dunefield, would result in negative impacts of medium to high significance. While the impacts are all mitigable to some extent, together they would result in a cumulative erosion of the integrity of the wetland / dunefield / terrestrial mosaic, and a resultant impact on biodiversity at a local (site), regional and national level.

It is only in the context of the potential retrieval of extensive areas of adjacent wetland currently under threat of approved or planned development, and assuming that there is a stringent application of the recommended “no development” areas outlined for this site, that the assessed cumulative impact of the development could change somewhat. Implementation of these measures would result in the conservation of a broad extent of wetlands in the Oyster Bay dunefield, as well as the Thysbaai dunefield and the Eastern valley bottom wetland. In such a case, and assuming that all recommended mitigation measures are effectively implemented, including the required provisos in terms of conservation management, there might be a somewhat better conservation outcome for wetlands than if the "no go" alternative for this site is pursued.

In conclusion, development of the Duynefontein site would be the alternative associated with the lowest level of negative environmental impact. Although the assessed impacts of the proposed NPS development at Bantamsklip are considered positive from a conservation perspective, the likely implications of transmission line impacts (not assessed in this study) inevitably tempers the positive rating of the development. Development of a NPS at Thyspunt does have the potential to be associated with positive impacts, provided that proposed impact mitigation measures are feasible to implement. In this case, development of a NPS at Thyspunt would be recommended from a wetland perspective, compared to the current "no development" alternative. This highlights the positive opportunities that a NPS site at Thyspunt could afford by way of wetland conservation, in the face of significant current threats to wetland conservation in the area. While development of a NPS at Bantamsklip could also be associated with significant conservation areas, the threats to wetlands associated with the "no-development" alternative are considered greater in the Thyspunt area than at the Bantamsklip site.

8 REFERENCES

Arcus Gibb, (2008). Nuclear 1 Environmental Impact Assessment. **Draft Environmental Scoping Report, July 2008**.

Bird, M. (2009). Investigating the feasibility of developing biotic indices for wetlands using aquatic invertebrates. **Draft report to the Water Research Commission for the Wetland Health and Integrity Research Programme**. WRC Project K5/1584.

Brown, DS. (1994). **Freshwater snails of Africa and their medical importance**. 76-81 pp. Taylor and Francis CRC Press, London. 608 p.

Clarke, K. R and R. M. Warwick (2001) **Change in marine communities: an approach to statistical analysis and interpretation, 2nd edition**. PRIMER-E, Plymouth.

Cole N.S., Lombard A.T., Cowling R.M, Euston-Brown D.I.W, Richardson D.M. & Heijnis C.E. (2000). **Framework for a conservation plan for the Agulhas Plain, Cape Floristic Region, South Africa.** 2nd Edition August 2000.

Cook, C. D. K. (2004) **Aquatic and wetland plants of southern Africa**. Backhuys Publishers. Leiden. The Netherlands.

Cowan, G.I. 1995 (ed.) **Wetlands of South Africa**. SA Wetlands Conservation Programme Series. Department of Environment Affairs and Tourism. Pretoria.

Cowling, R M (1983). Diversity relations in Cape shrublands and other vegetation in the southeastern Cape, South Africa. **Vegetation** 54: 103 – 127.

Cowling, R M (1996). Flora **and vegetation of Groot Hagelkraal (Bantamsklip site), Agulhas Plain**. Unpub. Report, Institute for Plant Conservation, University of Cape Town.

Dallas, H. and Rivers-Moore, N. (2008**). Adaptation to the consequences of climate change for freshwater resources.** Starter document. Workshop: 3 – 5 September 2008. Project for WWF Sanlam Freshwater Programme and the Water Research Commission.

Davies, B. R. and J. A. Day (1998) **Vanishing Waters**. University of Cape Town Press

Day, E. (2004). Chapter 8. Water Chemistry. IN Ractliffe, G. and Dallas, H (Eds). **Berg River Baseline Monitoring Programme. Initialisation Report: Volume 1. Introduction to the Berg River Catchment; groundwater and riverine environment.** Report to DWAF. Pretoria. Project No. 2002/069.

Day, E. (2005) **Proposed Wastewater Treatment Works, Pearly Beach. Assessment of Impacts to the Klein Hagelkraal River as a Result of Discharging Treated Effluent from the Proposed Pearly Beach WWTW**. Report to SRK Consulting.

Day, E. (2007a) **Nuclear 1 Environmental Impact Assessment and Environmental Management Programme: Specialist Study for Inception Report. Specialist Study: Wetland Ecosystems**. The Freshwater Consulting Group. Report to Arcus Gibb for Eskom (client).

Day, E. (2007b). **Assessment of the impacts potentially associated with the proposed extensions / upgrading of wastewater treatment works and associated infrastructure in the Blaauwberg administration area. Specialist study: freshwater ecosystems**. Report to CCA Environmental for the City of Cape Town.

Day, E. and Ewart-Smith, J. (2005). **Environmental Impact Assessment of the proposed upgrade of the Wesfleur Wastewater Treatment Works. Specialist study: freshwater ecosystems**. Report to CCA Environmental for the City of Cape Town.

Day, E., and Malan, H. (2009). **Final protocols for the Wetland Health and Integrity Research Programme.** Report to the Water Research Commission. WRC Project No. K5/1584.

Day, E., Ractliffe, G. and Wood, J. (2005). An audit of the ecological implications of remediation, management and conservation or urban aquatic habitats in Cape Town, South Africa, with reference to their social and ecological contexts. **Ecohydrology and hydrobiology***.* Vol 5:4.

Day, J.A. (1989). **Description and evaluation of the terrestrial and wetland ecosystems in the three southern Cape sites between Pearly Beach and Quoin Point**. Freshwater Research Unit Report.

Day, J.A., Day, E., Ross-Gillespie, V. and Ketley, A. (2009)**. A metric for the assessment of wetlands during dry conditions**. Report to the Water Research Commission. Wetland Health and Integrity Research Programme. WRC Project No. K5/1584.

de Moor and A.E. Louw (eds.) (2003). **Guides to the Freshwater Invertebrates of Southern Africa. Volume 4: Crustacea III**. WRC Report Number TT 141/01. Water Research Commission, Pretoria. 141p.

De Moor, F.C. and K.M.F. Scott. (2003). Trichoptera. Pp. 84-181. *In* I.J. de Moor, J.A. Day, and F.C. de Moor. (2003**). Guides to the Freshwater Invertebrates of Southern Africa. Volume 8: Insecta II.** WRC Report Number TT 214/03. Water Research Commission, Pretoria. 209 p.

Department of Water Affairs and Forestry. (2004). **Development of a framework for the assessment of wetland ecological integrity in South Africa. Phase 1: Situation Analysis. by MC Uys. Contributors G Marneweck and P Maseti**. Report No. 0000/00/REQ/0904 ISBN No.: 0-621-35474-0. Resource Quality Services, Department of Water Affairs and Forestry, Pretoria, South Africa.

Department of Water Affairs and Forestry (2005). **A practical field procedure for identification and delineation of wetland riparian areas**. Department of Water Affairs and Forestry, Pretoria, South Africa.

Department of Water Affairs and Forestry. (1996). **South African Water Quality Guidelines. Volume 7. Aquatic Ecosystems**. Pretoria.

Department of Water Affairs and Forestry. (2002). **National Eutrophication Monitoring Programme. Implementation Manual.** South African National Water Quality Monitoring Programmes Series. Pretoria.

Department of Water Affairs and Forestry. (1999**). Resource Directed Measures for Protection of Water Resources. Volume 3: River Ecosystems Version 1.0**, Pretoria. Resource Directed Measures for Protection of Water Resources, Pretoria, South Africa.

Epler, JH. (1996). **Identification manual for the water beetles of Florida (Coleoptera: Dryopidae, Dytiscidae, Elmidae, Gyrinidae, Haliplidae, Hydraenidae, Hydrophilidae, Noteridae, Psephenidae, Ptilodactylidae, Scirtidae).** Final Report DEP WM621, State of Florida Department of Environmental Protection, Division of Water Facilities, Tallahassee, FL. 259 p.

Eskom. (2009). **Approach to the control of groundwater on the Thyspunt Site for new Nuclear Power Plant Installations. Position Report**. Civil Engineering Technical Report. Report prepared by Lee, D.E. Revision date 30 September 2009. 17pp.

Eskom. (2008a). **Civil Engineering Technical Report. Duynefontein Site. Services Report**.

Eskom. (2008b). **Civil Engineering Technical Report. Bantamsklip Site. Services Report**.

Eskom. (2008c). **Civil Engineering Technical Report. Thyspunt Site. Services Report.**

Eskom. (2008d). **Disposal of excavated Sand. Conceptual Arrangement. Thyspunt site**. Nuclear1 PSSR: Thyspunt

Eskom. (2008e). Oceanography and Coastal Engineering. Nuclear1 PSSR: Thyspunt

Eskom. (2008f). **Oceanography and Coastal Engineering. Nuclear1 PSSR: Bantamsklip**

Eskom. (1994). **Eastern Cape Summary Report. Eskom Nuclear Site Specific Investigations**.

Euston-Brown, D. (2003). **Proposed wastewater treatment works. Pearly Beach. Botanical impact assessment.** Report to SRK consulting for Overstrand Municipality.

Ewart-Smith, J., Ollis, D., Day, J. and Malan, H. (2006). **National Wetland Inventory: Development of a wetland classification system for South Africa**. Water Research Commission Report.

Griffiths, C.L. and B.A. Stewart. (2001). Amphipoda. Pp. 28-49

Hall, D.J. (1990). **The ecology and control of *Typha capensis* in the wetlands of the Cape Flats, South Africa.** Unpublished PhD Thesis, Zoology Department, University of Cape Town. 249 pp.

Harrison, J.A., Burger, M. and Stoffberg, S. (2009). **Environmental Impact Assessment for the proposed Nuclear Power Station ('Nuclear1') and associated infrastructure. Terrestrial Vertebrate Fauna.** Draft Report by JAH Environmental Consultancy to Arcus Gibb for Eskom.

Illenberger, W. (2009). **Environmental Impact Assessment of the proposed Nuclear Power Station ("Nuclear-1") and associated infrastructure. Draft 3.** September 2009 Report to Arcus Gibb for Eskom Holdings Limited.

Illenberger, W. (2009). **Addendum to Dune Geomorphology Impact Assessment: debris flows in the Sand River and potential for flood damage to the R330.** September 2010 Report to Arcus Gibb for Eskom Holdings Limited.

Illenberger, W.K. & Burkinshaw, J.R. (2008). Coastal dunes and dunefields. In **The geomorphology of the Eastern Cape, South Africa,** Second Edition. pp 71-86. Edited by C A Lewis, published by Grocott and Sherry, Grahamstown, 188 pp.

Intergovernmental Panel on Climate Change (IPCC). (2008). **Technical paper on climate change and water.**

IUCN. (2008). 2008. **IUCN Red List of Threatened Species**. www.iucnredlist.org. August 2008.

Jones, M.G.W., G.D.P. van Nieuwenhuizen and J.A. Day. (2002). **Selecting priority wetlands for conservation measures. The Agulhas Plain as a case study**. Report to CAPE (Cape Action Plan for the environment).

Kadlec, R. and Knight, R. 1996. **Treatment wetlands**. Lewis Publishers. New York. Pp 893.

Kensley, B. (2001). Tanaidacea. Pp. 80-86. *In* R. Stals and I.J. de Moor (eds.) **Guides to the Freshwater Invertebrates of Southern Africa. Volume 4: Crustacea III.** WRC Report Number TT 141/01. Water Research Commission, Pretoria. 141p.

La Cock, G.D. and Burkinshaw, J.R. (1996) Management implications of development resulting in disruption of a headland bypass dunefield and its associated river, Cape St. Francis, South Africa**. Landscape and Urban Planning**. 34: 373-381.

Low, A.B. (2009). **Environmental Impact Assessment for the proposed Nuclear Power Station ('Nuclear1') and associated infrastructure. Botanical study and terrestrial Ecology**. Draft Report to Arcus Gibb for Eskom.

Macfarlane, D. M, D. Kotze, W. Ellery, D. Walters, V. Koopman, P. Goodman and C. Gorge (2008) **WET-Health: A technique for rapidly assessing wetland health**. WRC Report no. TT 340/08, Water Research Commission, Pretoria, South Africa.

Malan, H. and Day, J.A. (2005**). Assessment of trophic status in aquatic resources with particular reference to the water quality reserve**. WRC Report No 1311/2/05.

Martens, K. (2001). Ostracoda. Pp. 9-77. *In* J.A. Day, I.J. de Moor, B.A. Stewart, and A.E. Louw (eds.). Guides to the Freshwater Invertebrates of Southern Africa. Volume 3: Crustacea II. WRC Report Number TT 148/01. Water Research Commission, Pretoria. 177p.

Monaghan, M.T., J.L. Gattolliat, M. Sartori, J.M. Elouard, H. James, P. Derleth, O. Glaizot, F. de Moor, and A.P. Vogler. (2005). Transoceanic and endemic origins of the small minnow mayflies (Ephemeroptera, Baetidae) of Madagascar**. Proceedings of the Royal Society:** 272: 1829-1836.

Mucina, L. and Rutherford, M.C. (eds) (2006). The vegetation of South Africa, Lesotho and Swaziland. **Strelitzia** 19. South African National Biodiversity Institute. Pretoria.

New M. 2002. Climate change and water resources in the south western Cape, South Africa. **South African Journal of Science** 98: 1-8.

Prestedge, Retief, Dresner & Wijnberg (2009). **Environmental impact assessment for the proposed nuclear power station and associated infrastructure: estimating the 1:100 year flood line from the sea.** Prestedge, Retief, Dresner & Wijnberg (Pty) Ltd.)

Rayner, N.A. (2001). Copepoda. Pp. 78-123. *In* JA Day, IJ de Moor, BA Stewart, and AE Louw (eds**). Guides to the Freshwater Invertebrates of Southern Africa. Volume 3: Crustacea II**. WRC Report Number TT 148/01. Water Research Commission, Pretoria. 177p.

SANBI (2009) **Proposed National Wetland Classification System for South Africa. Final Project Report.** Prepared by the Freshwater Consulting Group (FCG) for the South African National Biodiversity Institute (SANBI).

Schael, D. (2008**). Notes on invertebrates at west and south coast sites**. Comments report to FCG.

Seaman, MT, D.J Kok and M Watson. (2000). Cladocera. Pp. 81-110. *In* JA Day, BA Stewart, IJ de Moor and AE Louw (eds). **Guides to the Freshwater Invertebrates of Southern Africa. Volume 2: Crustacea I**. WRC Report Number TT 121/00. Water Research Commission, Pretoria. 126 p.

Semlitsch, R.D. & Bodie, J.R. (2003). Biological Criteria for Buffer Zones around Wetlands and Riparian Habitats for Amphibians and Reptiles. **Conservation Biology**, Vol. 17, No. 5. pp. 1219 – 1228.

SRK, (2009). **Nuclear 1 Environmental Impact Assessment and Environmental Management Programme. Specialist Study for Environmental Impact Report: Geohydrology.** Report prepared for Eskom Holdings Limited, Generation Division. SRK Consulting.

SRK. (2007). **Nuclear 1 Environmental Impact Assessment and Environmental Management Programme – Specialist Study for Inception Report. Specialist Study: Geohydrology,** NSIP-NSI-020566#P1-59, J27035, November 2007. Report prepared for Eskom Holdings Limited, Generation Division. SRK Consulting.

Stals, R. and I.J. de Moor. (2007). **Guides to the Freshwater Invertebrates of Southern Africa. Volume 10: Coleoptera.** WRC Report Number TT 320/07. Water Research Commission, Pretoria. 263 pp.

Tolley, K. and Burger, M. (2007). **Chameleons of southern Africa**. Struik Publishers. South Africa. 100pp.

Visser, D., Dennis, I., Day, E. (Liz) and Rosewarne, P. 2011. **Additional Wetlands Monitoring on Proposed Eskom Nuclear Sites Thyspunt, Bantamsklip and Duynefontein.** Draft report to Eskom.

Wetland Consulting Services. (2009). T**hyspunt Wetlands: Management implications based on hydrological considerations.** Report to Nuclear Structural Engineering (NSE).

APPENDICES

APPENDIX A

Revised classification of inland wetlands, after Ollis *et al*. (2008).

LEVEL 1: SYSTEM	LEVEL 2: REGIONAL SETTING & VEGETATION TYPE			LEVEL 3: LANDSCAPE UNIT	LEVEL 4: HY
CONNECTIVITY TO OPEN OCEAN	*ECOREGION*	*BIOREGION*	*VEGETATION UNIT*	*LANDSCAPE SETTING*	*LANDFORM (GEOMO*
	A	B	C		A
INLAND	DWAF Level I Ecoregions	Bioregions of SA Vegetation Map (Mucina & Rutherford 2006)	Vegetation Units of SA Vegetation Map (Mucina & Rutherford 2006)	MAJOR CHANNEL (river)	Mountain headwater
					Mountain stream
					Transitional
					Upper foothill
					Lower foothill
					Lowland
				VALLEY BOTTOM	Channelled valley bottom
					Floodplain
					Unchannelled valley bottom
				SLOPE	Head slope
					Hillslope
				HILLTOP (crest)	
				PLAIN	Channelled plain
					Floodplain
					Unchannelled plain

APPENDIX B

Environmental Importance and Sensitivity (EIS) protocol for wetlands

The method used to assess the EIS of wetlands is a refinement of the DWAF Resource Directed Measures for Water Resources: Wetland Ecosystems method (DWAF, 1999b). It includes an assessment of ecological (e.g. presence of rare and endangered fauna / flora), functional (e.g. groundwater storage / recharge) and socio-economic criteria (e.g. human use of the wetland).

Scoring of these criteria then places the wetland in a Wetland Importance Class (A-D) (see Table B1).

Table B1 Wetland Importance Class integrating Ecological Importance and Sensitivity, and functional and socio-cultural importance modifiers.

Importance class (one or more attributes may apply)	Range of Median	Wetland Importance Class
Very high Representative of wetlands that: • support key populations of rare or endangered species; • have a high level of habitat and species richness; • have a high degree of taxonomic uniqueness and/or intolerant taxa; • provide unique habitat (e.g. salt marsh or ephemeral pan; physiognomic features, spawning or nursery environments); • is a crucial avifaunal migratory node (e.g. RAMSAR wetlands); • may provide hydraulic buffering and sediment retention for large to major rivers that originate largely outside of urban conurbations; • have groundwater recharge/discharge comprising a major component of the hydrological regime of the wetland; • are highly sensitive to changes in hydrology, patterns of inundation, discharge rates, water quality and/or disturbance; and • are of extreme importance for conservation, research or education.	>3 <=4	A
High Representative of wetlands that: • support populations of rare or endangered species, or fragments of such populations that are present in other similar and geographically-adjacent wetlands; • contain areas of habitat and species richness; • contain elements of taxonomic uniqueness and/or intolerant taxa; • contain habitat suitable for specific species (e.g. physiognomic features); • provide unique habitat (e.g. salt marsh or ephemeral pan; spawning or nursery environments, heronries); • may provide hydraulic buffering and sediment retention for rivers that originate largely outside of urban conurbations, or within residential fringes of urban areas; • have groundwater recharge/discharge comprising a component of the hydrological regime of the wetland; • may be sensitive to changes in hydrology, patterns of inundation, discharge rates, water quality and/or human disturbance; and • are important for conservation, research, education or eco-tourism.	> 2 <= 3	B
Moderate Representative of wetlands that: • contain small areas of habitat and species richness; • provide limited elements of habitat that has become fragmented by	>1 <= 2	C

development (e.g. salt marsh, ephemeral pan; roosting sites and heronries); • provide hydraulic buffering for rivers that originate in urban areas; • are moderately sensitive to changes in hydrology, patterns of inundation, discharge rates and/or human disturbance; • perform a moderate degree of water quality enhancement, but are insensitive to sustained eutrophication and/or pollution; and • are of importance for active and passive recreational activities.		
Low/marginal Representative of wetlands that: • contain large areas of coarse (reeds) wetland vegetation with minimal floral and faunal diversity; • have a high urban watershed:wetland area ratio; • are important for active and passive recreation; • provide moderate to high levels of hydraulic buffering; • may be eutrophic and generally insensitive to further nutrient loading; • are generally insensitive to changes in hydrology, patterns of inundation, discharge rates and/or human disturbance; • have regulated water; and • contain large quantities of accumulated organic and inorganic sediments.	>0 <= 1	D

APPENDIX C

Protocols for the assessment of Present Ecological Status in wetlands:

Level 2 WET-Health assessment (Mc Farlane *et al*. 2008)

WET-Health is based on the assessment of each hydrogeomorphological (HGM) unit in a selected wetland in terms of three modules, namely wetland hydrology, geomorphology and vegetation. The tool does not, at present, allow for an assessment of water quality.

Tables C1 to C3 summarise the steps taken in the assessment of each module, which is scored, using the guidelines in McFarlane *et al*. (2008). Table C4 summarises the relationship between WET-Health score for each module, and PES category.

Although the WET-Health methodology does not encourage aggregation of scores for the three modules, McFarlane *et al*. (2008) provide the following formula to undertake this process when deemed necessary:

"Health" = ((Hydrology score)x3) + ((Geomorphology score)x2)/7) + ((Vegetation score)x2)/7)"

Table C1 Summary of assessment steps in WET-Health Hydrology module (after McFarlane *et al*. 2008)

Wet-Health	Hydrology Module	Version 1.0

PAGE 1: SUMMARY PAGE

STEP 1: IDENTIFY HGM UNITS IN THE WETLAND AND DESCRIBE THE LOCAL CLIMATE

STEP 1A: IDENTIFY THE HGM TYPES IN THE WETLAND AND DIVIDE THE WETLAND INTO HGM UNITS

HGM Unit	Ha	Extent (%)
1		#DIV/0!
2		#DIV/0!
3		#DIV/0!
4		#DIV/0!
5		#DIV/0!
Total	0.0	100

Legend
Enter information

STEP 1B: ASSESS THE VULNERABILITY OF THE HGM UNIT TO ALTERED WATER INPUTS

Table 2.1: Flow alterarion factor combining the MAP:PET ratio and wetland area : catchment area ratio as a means of inferring (1) flow reduction potential and (2) vulnerability of the wetland to reduced flows

	MAP to PET ratio	>0.6	0.50-0.59	0.40-0.49	0.30-0.39	<0.3
Wetland area to catchment area ratio	>0.3	0.8	0.85	0.9	0.95	1
	0.21-0.3	0.85	0.9	0.95	1	1.05
	0.11-0.2	0.9	0.95	1	1.05	1.1
	0.05-0.1	0.95	1	1.05	1.1	1.15
	<0.05	1	1.05	1.1	1.15	1.2
	Flow alteration factor					

INDIVIDUAL ASSESSMENT OF EACH HGM UNIT (SEE SHEETS PROVIDED)

STEP 2: ASSESS IMPACT OF CHANGES IN QUANTITY AND PATTERN OF WATER INPUTS TO THE WETLAND

STEP 3: ASSESS THE DEGREE TO WHICH NATURAL WATER DISTRIBUTION AND RETENTION PATTERNS WITHIN THE WETLAND HAVE BEEN ALTERED AS A RESULT OF ON-SITE ACTIVITIES

STEP 4: ASSESS THE OVERALL HYDROLOGICAL HEALTH OF THE HGM UNIT BASED ON INTEGRATING THE ASSESSMENTS FROM STEPS 2 AND 3

STEP 5: DETERMINE THE HEALTH SCORE FOR THE OVERALL WETLAND

Table 2.21: Derivation of the overall impact score for the wetland being considered.

HGM Unit	Area (Ha)	Extent (%)	HGM impact score - Table 2.20	Area weighted HGM score*
1	0	#DIV/0!	0	#DIV/0!
2	0	#DIV/0!	0	#DIV/0!
3	0	#DIV/0!	0	#DIV/0!
4	0	#DIV/0!	0	#DIV/0!
5	0	#DIV/0!	0	#DIV/0!
Total		#DIV/0!	Overall weighted impact score**	#DIV/0!
			Health Score	#DIV/0!
			Health Category	#DIV/0!

* The area-weighted average score is calculated as: Proportion of wetland as a percentage / 100 x HGM impact score.
** The total impact score for the wetland as a whole is calculated by summing the area-weighted HGM scores for each HGM unit.

Table 2.23: Health classes used by WET-Health for describing the integrity of wetlands.

Table C2 Summary of assessment steps in WET-Health Geomorphology module (after McFarlane *et al*. 2008)

Wet-Health	Geomorphology Module	Version 1.0

PAGE 1: SUMMARY PAGE

STEP 1: DIVIDE WETLAND INTO HGM UNITS

HGM Unit	Ha	Extent (%)
1		#DIV/0!
2		#DIV/0!
3		#DIV/0!
4		#DIV/0!
5		#DIV/0!
Total	0.0	100

Legend
Enter information

INDIVIDUAL ASSESSMENT OF EACH HGM UNIT (SEE SHEETS PROVIDED)

STEP 2: ASSESS CURRENT GEOMORPHIC INTEGRITY OF EACH HGM (STEPS 2A - D)

STEP 2F: ASSESS OVERALL GEOMORPHIC HEALTH FOR THE WETLAND

Table 3.15: Derivation of the overall impact score for the wetland being considered.

HGM Unit	Ha	Extent (%)	Overall impact score for HGM (Table 3.13)	Area weighted HGM score*
1	0	#DIV/0!	#DIV/0!	#DIV/0!
2	0	#DIV/0!	#DIV/0!	#DIV/0!
3	0	#DIV/0!	#DIV/0!	#DIV/0!
4	0	#DIV/0!	#DIV/0!	#DIV/0!
5	0	#DIV/0!	#DIV/0!	#DIV/0!
Total		#DIV/0!	Overall weighted impact score**	#DIV/0!
			Health Score (Table 3.16)	#DIV/0!
			Health Category (Table 3.17)	#DIV/0!

* The area-weighted average score is calculated as: Proportion of wetland as a percentage / 100 x HGM impact score.
** The total impact score for the wetland as a whole is calculated by summing the area-weighted HGM scores for each HGM unit.

Table 3.17: Health categories used by WET-Health for describing the geomorphic integrity of wetlands

HEALTH Category	DESCRIPTION	Score
A	Unmodified, natural.	9 - 10
B	Largely natural. A slight change in geomorphic processes is discernable but the system remains largely intact.	8 - 8.9
C	Moderately modified. A moderate change in geomorphic processes has taken place but the system remains predominantly intact.	6 - 7.9
D	Largely modified. A large change in geomorphic processes has occurred and the system is appreciably altered.	4 - 5.9
E	Greatly modified. The change in geomorphic processes is great but some features are still recognizable.	2 - 3.9
F	Modifications have reached a critical level. Geomorphic processes have been modified completely.	0 - 1.9

STEP 3: ASSESS VULNERABILITY AND THREAT POSED BY HEADCUT EROSION (STEPS 3A - G)

STEP 3H: ASSESS OVERALL THREAT OF HEADCUT/S AND CATCHMENT TO WETLAND HEALTH

Table 3.29: Derivation of the overall impact score for the wetland being considered.

Table C3 Summary of assessment steps in WET-Health Vegetation module (after McFarlane *et al*. 2008)

Wet-Health	Vegetation Module	Version 1.0

PAGE 1: SUMMARY PAGE

STEP 1: MAP AND DETERMINE THE EXTENT OF EACH HGM UNIT

HGM Unit	Ha	Extent (%)
1		#DIV/0!
2		#DIV/0!
3		#DIV/0!
4		#DIV/0!
5		#DIV/0!
Total	**0.0**	**100**

Legend
Enter information

INDIVIDUAL ASSESSMENT OF EACH HGM UNIT (SEE SHEETS PROVIDED)

STEP 2: MAP AND DETERMINE THE EXTENT OF EACH DISTURBANCE UNIT WITHIN EACH HGM UNIT

STEP 3: IN EACH DISTURBANCE UNIT ASSESS THE MAGNITUDE OF IMPACT OF ACTIVITIES THAT HAVE ALTERED THE NATURAL VEGETATION

STEP 4: DETERMINE THE IMPACT MAGNITUDE SCORE FOR EACH HGM UNIT

STEP 5: DETERMINE THE HEALTH SCORE FOR THE OVERALL WETLAND

Table 4.13: Summary impact score (adjusted to incorporate vulnerability) for each HGM unit

HGM Unit	Ha	Extent (%)	HGM impact score - Table 4.12	Area weighted HGM score*
1	0	#DIV/0!	#DIV/0!	#DIV/0!
2	0	#DIV/0!	#DIV/0!	#DIV/0!
3	0	#DIV/0!	#DIV/0!	#DIV/0!
4	0	#DIV/0!	#DIV/0!	#DIV/0!
5	0	#DIV/0!	#DIV/0!	#DIV/0!
Total		**#DIV/0!**	**Overall weighted impact score**	**#DIV/0!**
			Health Category	**#DIV/0!**

* The area-weighted average score is calculated as: Proportion of wetland as a percentage / 100 x HGM impact score.
** The total impact score for the wetland as a whole is calculated by summing the area-weighted HGM scores for each HGM unit.

Table 4.14: Health categories as described in the present wetland health assessment technique

HEALTH Category	DESCRIPTION	Score
A	Vegetation composition appears natural.	9 - 10
B	A very minor change to vegetation composition is evident at the site.	8 - 8.9
C	Compositional changes are evident but the site still contains mostly species expected in the reference state. Vegetation composition has been clearly altered but still contains a large proportion of natural species expected in the reference state.	6 - 7.9
D	Vegetation composition has been largely altered and introduced, alien and/or ruderal species are abundant but most characteristic wetland species are usually still present.	4 - 5.9
E	Vegetation composition has been substantially altered but some characteristic species remain, although the vegetation consists mainly of introduced, alien and/or ruderal species.	2 - 3.9
F	Vegetation composition has been totally or almost totally altered, and if any characteristic species still remain, their extent is very low.	0 - 1.9

STEP 6: COMPILE A SUMMARY TABLE REFLECTING CAUSES OF IMPACTS TO WETLAND VEGETATION

Table 4.15: Summary tables of factors contributing to the loss in vegetation integrity

Contributing factors

Table C4 Description of the Present Ecological State categories of WET-Health, showing the range of magnitude-of-impact scores used to categorise each HGM unit assessed. Table after Mc Farlane *et al*. (2008).

DESCRIPTION	WET-Health IMPACT SCORE	PRESENT STATE CATEGORY
Unmodified, natural.	0 – 0.9	A
Largely natural with few modifications. A slight change in ecosystem processes is discernable and a small loss of natural habitats and biota may have taken place.	1 – 1.9	B
Moderately modified. A moderate change in ecosystem processes and loss of natural habitats has taken place but the natural habitat remains predominantly intact	2 – 3.9	C
Largely modified. A large change in ecosystem processes and loss of natural habitat and biota and has occurred.	4 – 5.9	D
The change in ecosystem processes and loss of natural habitat and biota is great but some remaining natural habitat features are still recognizable.	6 – 7.9	E
Modifications have reached a critical level and the ecosystem processes have been modified completely with an almost complete loss of natural habitat and biota.	8 – 10	F

APPENDIX D

Protocols for the assessment of Present Ecological Status in wetlands: PES adapted from DWAF (1999)

The method used for the determination of the PES of each wetland is adapted from that described in Appendix W4 of the DWAF Resource Directed Measures for Water Resources: Wetland Ecosystems (DWAF 1999c). The method requires comparison of current attributes of the wetland against those of a desired baseline or reference condition. In order to be able to complete the PES assessment, the evaluator needs to take cognisance of the type of functions and services that the wetland would normally provide, or is required to provide. In this manner an assessment of deviation between the desired condition and that observed at the time of evaluation may be made. The services that wetlands provide may be broadly divided into ecological, functional and socio-cultural groups. While certain hydrological and hydraulic services provided by wetlands are often largely a factor of physical storage capacity, the ecological functioning, and socio-cultural benefits provided by the wetland depend to a large degree on the hydrological attributes of the wetland. If these are impaired in any sustained manner, the consequence may be, for example, that vegetative processes will be impaired, with knock-on effects in terms of habitat provision, biogeochemical cycling and production, as well as loss of aesthetic value.

The method requires the scoring of attributes associated with a particular criterion (see Table D1). The mean of all scores is then used to place the wetland in a conservation class (see Table D2).

Table D1 List of criteria and attributes considered in the evaluation of PES.

Criteria and attributes	Relevance
Hydrological	
Flow Modification	• flows reduced by abstraction (surface and/or groundwater, upstream or within wetland) or impoundment (dams, weirs or spillways), alien plant infestation or silviculture; • increased runoff from hardened catchment, agricultural drains, effluent disposal or change in watershed:wetland ratio; • alteration in flow regime (timing, duration, frequency, volume or velocity); • outflows constricted by vegetation; and • altered inundation pattern of wetland habitats resulting in floristic changes or incorrect cues to biota.
Permanent Inundation	impoundment or water level regulation resulting in destruction of natural wetland habitat.
Water Quality	
Water Quality Modification (nutrient loading and/or toxics and/or faecal pollution)	• from surface or groundwater point and/or diffuse sources (agricultural activities, human settlements, industrial or wastewater effluent); • internal loading from accumulated sediments; • aggravated by volumetric decrease in flow delivered to the wetland (scored under flow modification); and • change in ambient (desired) salinity as a consequence of altered freshwater or marine intrusion.
Sediment Load Modification	• reduction due to upstream retention by impoundment; and • increase due to land use practices such as overgrazing, unnatural rates of erosion or in-filling, and resulting in atypical accretion and/or turbidity.
Hydraulic/Geomorphic	
Canalisation/culverts	• desiccation, shrinkage, altered inundation patterns and changes in habitats; and • point discharges as opposed to broad or sheet flows.
Topographic Alteration/Habitat Fragmentation	• consequence of infilling, ploughing, dykes, causeways, trampling, bridges, roads, railway lines and other substrate disruptive physical changes that alter wetland habitat either directly or through changes in inundation patterns.

Criteria and attributes	Relevance
Biotic	
Terrestrial Encroachment	• desiccation of wetland and/or encroachment of terrestrial plant species due to changes in hydrology, geohydrology or geomorphology, resulting in a change from wetland to terrestrial (upland) habitat and associated loss of wetland function.
Loss of Shoreline (riparian) and/or fringing Vegetation (indigenous)	• loss or reduction in herbaceous or woody vegetation cover, and/or increased distance between upland vegetation and permanent water; • switch from macrophyte to algal dominance; • loss of critical riparian or upland vegetation as a consequence of development, farming activities, grazing or firewood collection affecting wildlife habitat, overland attenuation of flows, input of organic matter or increased potential for erosion; • loss of shading.
Invasive Plant Encroachment	• altered habitat characteristics through changes in community structure and/or water quality (oxygen reduction and shading).
Faunal Disturbance/ Alien Fauna	• faunal disturbance due to human presence, domestic animals, noise, light, footpaths, roadways, airports, electricity servitudes; • presence of alien fauna affecting faunal community structure (e.g. top down imbalance due to coarse fish, excessive zooplankton grazing etc; bird predation; gerbils); and • atypical fauna due to human presence.
Over utilisation of biota	overgrazing, fishing, mowing, burning or harvesting leading to alterations and imbalances in community structure and food web interactions.

Table D2 Interpretation of PES score.

Score	Wetland Description	PES Category	
> 4	Unmodified or approximates natural condition	A	Acceptable Condition
> 3 <=4	Largely natural with few modifications, minor loss of habitat	B	
> 2 <=3	Moderately modified with some loss of habitat	C	
= 2	Largely modified with loss of habitat and wetland functions	D	
> 0 < 2	Seriously modified with extensive loss of habitat and wetland function.	E	Unacceptable Condition
0	Critically modified. Losses of habitat and function are almost total, and the wetland has been modified completely.	F	

APPENDIX E

Regional perspective of aquatic invertebrate communities assessed at the three proposed Nuclear1 sites

In order to provide a broader, regional perspective of aquatic invertebrate fauna at the three study sites considered in the Nuclear1 freshwater ecosystems EIA (i.e. Duynefontein, Bantamsklip and Thyspunt), invertebrate data were included in a database of invertebrates occurring in similar wetland types, within the western and south western Cape region. This data was compiled as part of the (then) Department of Water Affairs and Forestry (DWAF)'s Water Research Commission's Wetland Health and Integrity Programme, and comprised data collected by Matt Bird (University of Cape Town) and presented in Bird (2009) and Day et al. (2009).

A multivariate analysis was applied to these data, using the computer package PRIMER (Clarke and Warwick 2001). Invertebrate samples from 71 wetland sites (Table E1) were analysed using the Bray-Curtis similarity index and graphically represented using a cluster diagram and multidimensional scaling (MDS) plots (Figures E2-E4). The samples representing each wetland site were assigned specific areas or geographical regions represented *a priori* and analyzed to determine if there were regional differences in invertebrate assemblages.

The Bray-Curtis cluster analysis showed five main groups of sites separating from one another. The group of sites separating out at less than 10% similarity to the other samples (Group 1) comprised samples from all three of the three Nuclear1 sites (Figures E2 and E3). Subgroups within Group 1 included the coastal seep (TP_CS) from Thyspunt and one of the coastal dune slack wetlands at Bantamsklip (BAN_GH1), which were only loosely affiliated with the other sites and formed outliers in the MDS plot (Figure E3). The other sub-group within Group 1 was that of the Koeberg sites.

The other four groups differentiated at between 20 and 30% similarity comprised dune slack depressions sampled around the region. The sites comprising each of these groupings were all geographically close together

A SIMPER (similarity percentage) analysis within PRIMER was done to ascertain which invertebrate taxa within each group were important most in defining that group. None of the groups had large within-group similarity (Table E2), but there was a clear pattern set by re-occurring taxa within the sites in each grouping.

Group 1 was defined predominantly by the dominant presence of insect taxa and low diversity of microcrustaceans. The subgroups within Group 1 (Groups 1A and 1B) separated out as a result of low diversity. Group 1A (representing the coastal seeps at Thyspunt) had only 10 taxa in total, and was dominated by marine amphipods and isopods, whereas 1B (an artificial body of open water at Bantamsklip) was dominated by dipterans and few other insect taxa.

Group 1C was closer in character to other wetland sites in the database, having microcrustaceans as well as other insect taxa. It did not however group with other samples collected from the Koeberg sites in spring 2008 – these formed part of Group 5. A major reason for this anomaly is probably related to the fact that the regional database samples were collected later in the wet season, when the microcrustacean community was more fully developed and thus reflected greater species diversity and higher numbers of microcrustaceans.

The remaining groups contained a mix of benthic as well as non-benthic microcrustaceans insects and benthic insects. It must be noted that although this analysis allows comparison of data from the three assessed sites with data from the region, the analysis is also beset with serious problems, including the following:

- Separation of the Duynefontein / Koeberg sites (Koe and Ks) between studies highlighted:
    - the difficulty of timing of the sampling of seasonally inundated systems – it is easy to miss whole orders of invertebrates by sampling too early or late in the season
    - the difficulty of comparing data collected in different studies using different techniques – e.g. Bird (2009) calculated abundance data based on volumes of water netted, while this study used the abundance methodology used in river SASS5 bioassessments – that is, a log-scale of abundance in a sample collected over a set period of time
- Identification of invertebrates to different taxonomic levels – Bird (2009) identified certain suites of invertebrates (e.g. coleopteran) to higher levels than occurred during this study; whilst this study identified chironomid and certain microcrustacean taxa to higher levels than did Bird

- Habitat types differed between samples – the Bantamsklip samples for example were collected from a permanently inundated (artificially excavated) depression; the coastal seep wetlands are permanently inundated, and the rest of the sites were all seasonally inundated.

- Separation of the Thyspunt coastal seep samples from the rest is not surprising – these systems are clearly very different in terms of their water chemistry and environment.

- The Thyspunt dune slack wetlands (TP2A, TP1B and TP1C) are also very different from the depressional wetlands sampled elsewhere, as they are individually spatially impermanent – that is, the wetlands disappear as the dunes move across them, reforming at other low points – they are thus unlikely to be colonized by taxa that rely on diapause for recolonisation of the same system, at a later time – the dune slack wetlands require colonization by mobile species or those that are carried by the wind or birds. This would account for the low numbers of microcrustacean species in these wetlands.

Table E1 **List of site codes, site names, geographical areas and level of immediate site disturbance of the invertebrate data used for analysis. Sites in the present study areas are highlighted in italics**

Site Code	Name	Sub-Area	Area	Disturbance Level
BAD 01	Baden Powell	Khayelitsha	Cape Flats	low
BAN GH1	*Bantamsklip*	*Bantamsklip*	*South Coast*	*low*
BAN GH4	*Bantamsklip*	*Bantamsklip*	*South Coast*	*low*
DAR 01	Darling	Darling	West Coast	moderate
DAR 02	Darling	Darling	West Coast	high
DAR 03	Darling	Darling	West Coast	high
DAR 04	Darling	Darling	West Coast	very low
DAR 05	Darling	Darling	West Coast	very low
DAR 06	Darling	Darling	West Coast	moderate
DAR 07	Darling	Darling	West Coast	very low
DAR 08	Darling	Darling	West Coast	very low
DAR 09	Darling	Darling	West Coast	moderate
DIE 04	Diepriver	Malmesbury	West Coast	high
DRE 01	Dream world	Khayelitsha	Cape Flats	low
DRE 02	Dream world	Khayelitsha	Cape Flats	low
KOE 01	*Koeberg*	*Koeberg*	*West Coast*	*low*
KOE 02	*Koeberg*	*Koeberg*	*West Coast*	*low*
KOE 03	*Koeberg*	*Koeberg*	*West Coast*	*low*
KOE 04	*Koeberg*	*Koeberg*	*West Coast*	*low*
KOE 05	*Koeberg*	*Koeberg*	*West Coast*	*low*
KOE 06	*Koeberg*	*Koeberg*	*West Coast*	*low*
KS1	*Koeberg*	*Koeberg*	*West Coast*	*low*
KS2	*Koeberg*	*Koeberg*	*West Coast*	*low*
KW 01	Kenilworth	Kenilworth	Cape Flats	low

Site Code	Name	Sub-Area	Area	Disturbance Level
KW 02	Kenilworth	Kenilworth	Cape Flats	low
KW 03	Kenilworth	Kenilworth	Cape Flats	very low
KW 04	Kenilworth	Kenilworth	Cape Flats	low
KW 05	Kenilworth	Kenilworth	Cape Flats	low
KW 06	Kenilworth	Kenilworth	Cape Flats	very low
KW 07	Kenilworth	Kenilworth	Cape Flats	very low
KW 08	Kenilworth	Kenilworth	Cape Flats	very low
KW 09	Kenilworth	Kenilworth	Cape Flats	very low
KW 10	Kenilworth	Kenilworth	Cape Flats	very low
KW 11	Kenilworth	Kenilworth	Cape Flats	very low
KW 12	Kenilworth	Kenilworth	Cape Flats	very low
KW 13	Kenilworth	Kenilworth	Cape Flats	very low
KW 14	Kenilworth	Kenilworth	Cape Flats	moderate
KW 15	Kenilworth	Kenilworth	Cape Flats	low
KW 16	Kenilworth	Kenilworth	Cape Flats	low
KW 17	Kenilworth	Kenilworth	Cape Flats	low
KW 18	Kenilworth	Kenilworth	Cape Flats	low
KW 19	Kenilworth	Kenilworth	Cape Flats	low
LOT 01	Zeekoevlei	Rondevlei	Cape Flats	low
LOT 02	Zeekoevlei	Rondevlei	Cape Flats	low
LOT 03	Lotus	Rondevlei	Cape Flats	low
LOT 04	Lotus	Rondevlei	Cape Flats	high
LOT 05	Lotus	Rondevlei	Cape Flats	high
LOT 06	Lotus	Rondevlei	Cape Flats	high
LOT 07	Lotus	Rondevlei	Cape Flats	moderate
LOT 08	Lotus	Rondevlei	Cape Flats	moderate

Site Code	Name	Sub-Area	Area	Disturbance Level
LOT 09	Lotus	Rondevlei	Cape Flats	very low
LOT 10	Lotus	Rondevlei	Cape Flats	very low
LOT 11	Lotus	Rondevlei	Cape Flats	very low
MFU 01	Mfuleni	Khayelitsha	Cape Flats	moderate
MFU 03	Mfuleni	Khayelitsha	Cape Flats	high
PIK 01	Piketberg	Piketberg	West Coast	moderate
PIK 06	Piketberg	Piketberg	West Coast	high
PIK 11	Piketberg	Piketberg	West Coast	high
SOU 01	Sout River	Koeberg	West Coast	moderate
SOU 02	Sout River	Koeberg	West Coast	high
SOU 03	Sout River	Koeberg	West Coast	high
SOU 04	Sout River	Koeberg	West Coast	moderate
TP 1B	*Thyspunt*	*Thyspunt*	*South Coast*	*low*
TP 1C	*Thyspunt*	*Thyspunt*	*South Coast*	*low*
TP 2A	*Thyspunt*	*Thyspunt*	*South Coast*	*low*
TP CS	*Thyspunt*	*Thyspunt*	*South Coast*	*low*
TP Dam	*Thyspunt*	*Thyspunt*	*South Coast*	*low*
TP Doep	*Thyspunt*	*Thyspunt*	*South Coast*	*low*
VEL 01	Veldrift	Veldrift	West Coast	high
VEL 02	Veldrift	Veldrift	West Coast	high
YZE 02	Yzerfontein	Yzerfontein	West Coast	moderate

Table E2 Taxa that define each clustered group of wetland sites by contributing ±40% of the within group similarity

Group	Taxa	
Group1 **41% similarity**	*Cricotopus* spp. larvae	Chironomidae
	Caenis sp.	Ephemeroptera
	Ischnura senegalensis	Odonata
	Oxyethira velocipes	Trichoptera
Group 2 **23% similarity**	*Polypedilum* spp. larvae	Chironomidae
	Metadiaptomus capensis	Calanoida
Group 3 **35% similarity**	*Microcyclops crassipes*	Cyclopoida
	Culiseta spp. larvae	Diptera
	Paracymus spp.	Coleoptera
Group 4 **35% similarity**	*Microcyclops crassipes*	Cyclopoida
	Cypricercus episphaena	Ostracoda
	Daphnia pulex/obtusa	Cladocera
	Simocephalus spp.	Cladocera
	Acarina sp.	Acarina
Group 5 **38% similarity**	*Cloeon* spp.	Ephemeroptera
	Microcyclops crassipes	Cyclopoida
	Metadiaptomus capensis	Calanoida
	Culicidae spp. pupae	Diptera
	Moina brachiata	Cladocera
	Orthocladiinae spp. larvae	Chironomidae

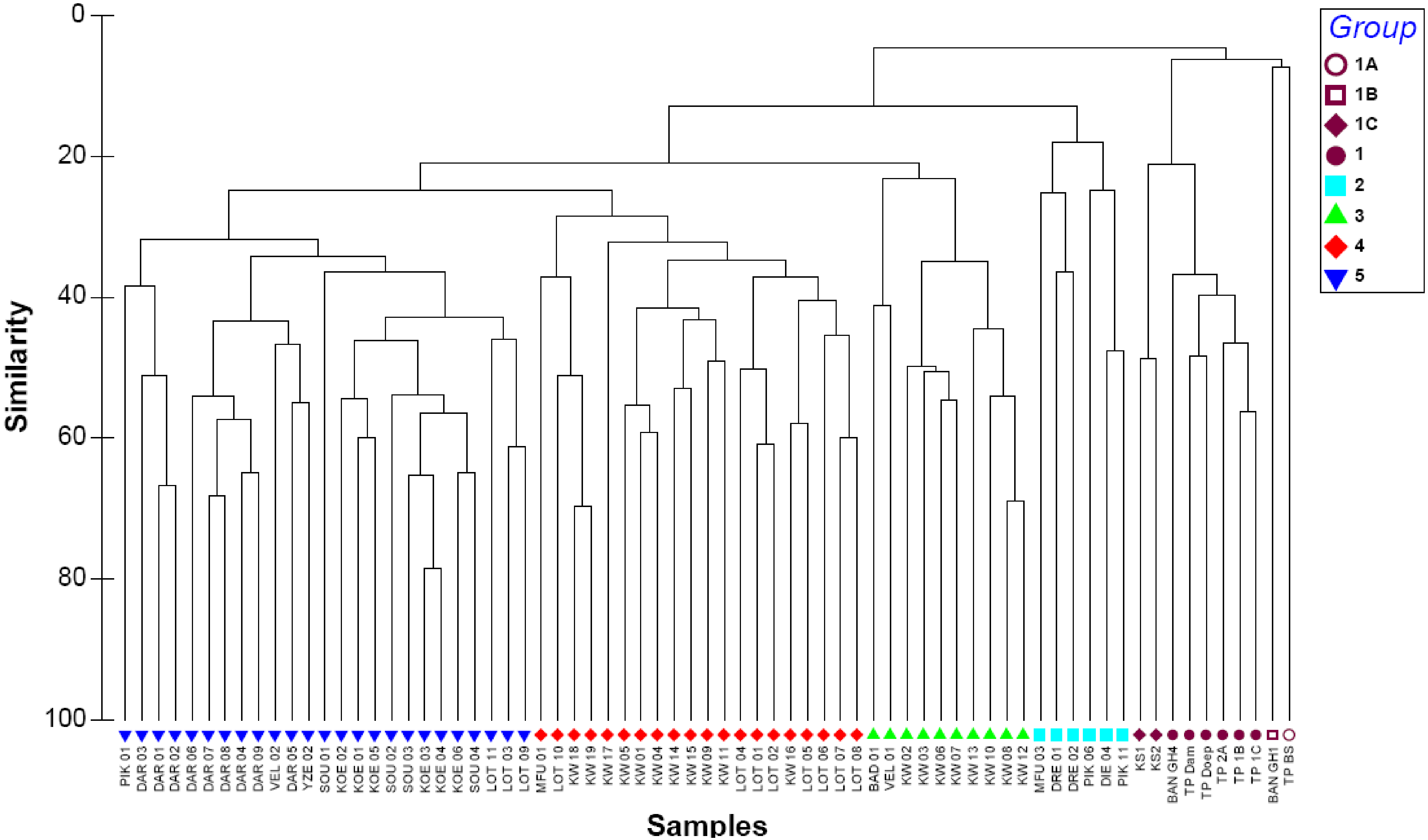


Figure E1 Bray-Curtis similarity cluster diagram showing the relationship between sites, five major groups are demarcated with unique symbols

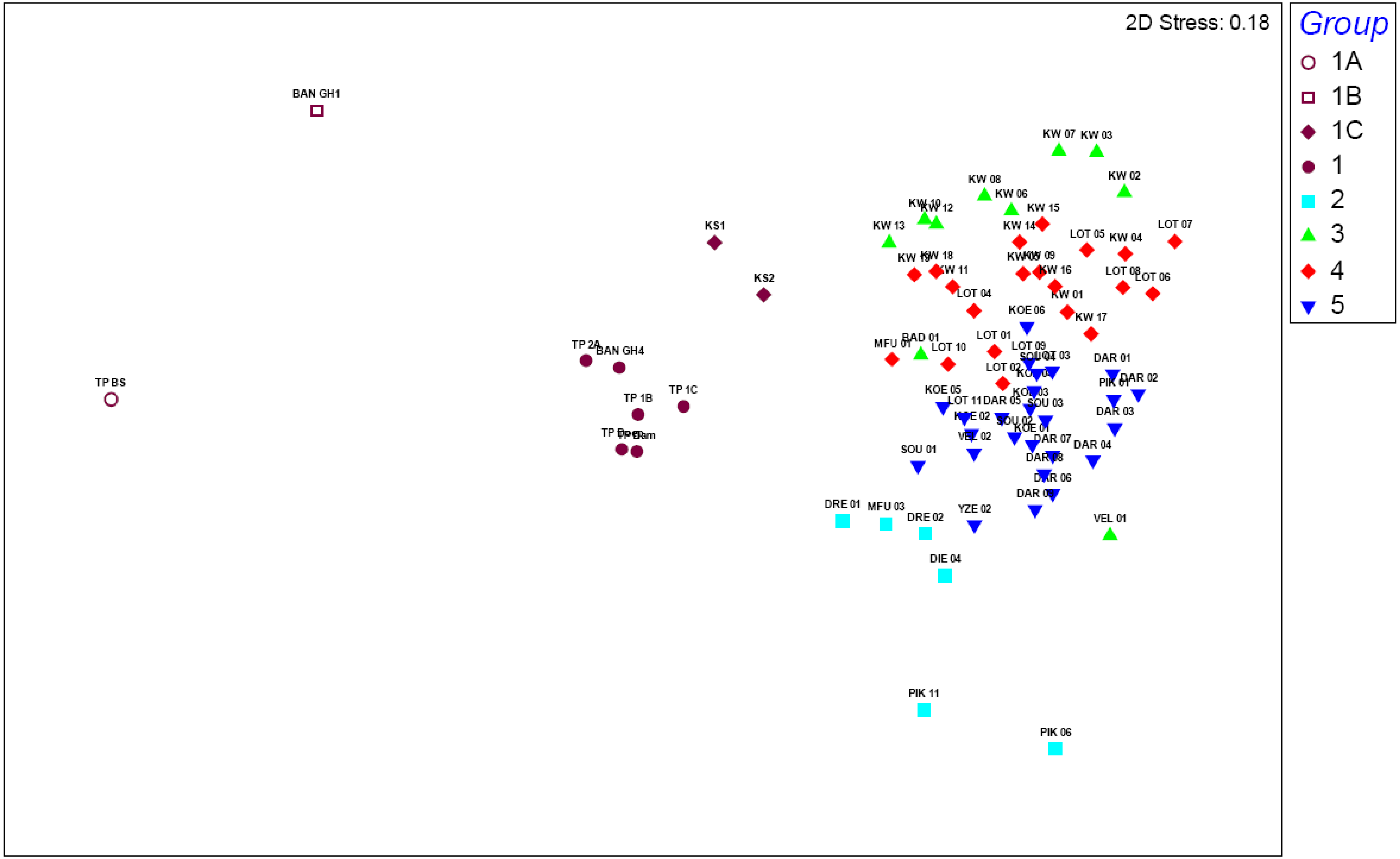


Figure E2 Bray-Curtis similarity of seasonal wetland sites by cluster group

APPENDIX F

Impact Assessment Rating Criteria

In accordance with Government Notice R.385, promulgated in terms of Section 24 of the NEMA and the criteria drawn from the IEM Guidelines Series, Guideline 5: Assessment of Alternatives and Impacts, published by the DEAT (April 1998) as well as the Guideline Document on Impact Significance (DEAT 2002), specialists were required to assess the potential impacts in terms of the criteria listed in **Table F1** below.

The assignment of ratings has been undertaken based on past experience of the EIA team, and the professional judgement of the specialists.

Table F1 Impact assessment criteria and rating scales

Criteria	Rating Scales	Notes
Nature	**Positive**	This is an evaluation of the type of effect the construction, operation and management of the proposed NPS development would have on the affected environment.
	Negative	
	Neutral	
Extent	**Low**	Site-specific, affects only the development footprint
	Medium	Local (limited to the site and its immediate surroundings, including the surrounding towns and settlements within a 10 km radius);
	High	Regional (beyond a 10 km radius) to national
Duration	**Low**	0-3 years (i.e. duration of construction phase)
	Medium	4 - 8 years
	High	9 years to permanent
Intensity	**Low**	Where the impact affects the environment in such a way that natural, cultural and social functions and processes are minimally affected
	Medium	Where the affected environment is altered but natural, cultural and social functions and processes continue albeit in a modified way; and valued, important, sensitive or vulnerable systems or communities are negatively affected

Criteria	Rating Scales	Notes
	High	Where natural, cultural or social functions and processes are altered to the extent that the impact will temporarily or permanently cease; and valued, important, sensitive or vulnerable systems or communities are substantially affected.
Potential for impact on irreplaceable resources	**Low**	No irreplaceable resources will be impacted.
	Medium	Resources that will be impacted can be replaced, with effort.
	High	There is a high potential that irreplaceable resources will be lost.
Consequence (a combination of extent, duration, intensity and the potential for impact on irreplaceable resources).	**Low**	A combination of any of the following • Intensity, duration, extent and impact on irreplaceable resources are all rated low • Intensity is low and up to two of the other criteria are rated medium • Intensity is medium and all three other criteria are rated low
	Medium	• Intensity is medium and at least two of the other criteria are rated medium
	High	• Intensity and impact on irreplaceable resources are rated high, with any combination of extent and duration • Intensity is rated high, with all of the other criteria being rated medium or higher.
Probability (the likelihood of the impact occurring)	**Low**	It is highly unlikely or less than 50 % likely that an impact will occur.
	Medium	It is between 50 and 74 % certain that the impact will occur.
	High	It is more than 75% certain that the impact will occur or it is definite that the impact will occur.
Significance (all impacts including potential cumulative impacts)	**Low**	• Low consequence and low probability • Low consequence and medium probability
	Low to medium	• Low consequence and high probability • Medium consequence and low probability
	Medium	• Medium consequence and low probability • Medium consequence and medium probability • Medium consequence and high probability • High consequence and low probability
	Medium to high	• High consequence and medium probability
	High	• High consequence and high probability

An explanation of the above-mentioned impact criteria is provided below. Only the above-mentioned criteria were taken into account in the assessment of impact significance. In addition, the degree of confidence in the prediction of impacts, the nature of applicable mitigation measures and legal requirements applicable to the impacts have been described by the specialists.

A. Nature

This is an evaluation of the type of effect the construction, operation and management of the proposed NPS development would have on the affected environment. Will the impact change in the environment be positive, negative or neutral? This description must include what will be affected and the manner in which the effect will transpire.

B. Extent or scale

This refers to the spatial scale at which the impact will occur. Extent of the impact is described as: low (site-specific - affecting only the footprint of the development), medium (limited to the site and its immediate surroundings and closest towns) and high (regional and national).

C. Duration

The lifespan of the impact is indicated as low (short-term - 0-3 years, typically impacts that are quickly reversible within the construction phase of the project), medium-term (3-15 years, reversible over time) and high (long-term, 15-60 years, and continue for the operational life span of the power station).

D. Intensity or severity

This is a relative evaluation within the context of all the activities and the other impacts within the framework of the project. Does the activity destroy the impacted environment, alter its functioning, or render it slightly altered? The specialist studies must attempt to quantify the magnitude of the impacts and outline the rationale used.

E. Impact on irreplaceable resources

This refers to the potential for an environmental resource to be replaced, should it be impacted. A resource could possibly be replaced by natural processes (e.g. by natural colonisation from surrounding areas), through artificial means (e.g. by reseeding disturbed areas or replanting rescued species) or by providing a substitute resource, in certain cases. In natural systems, providing substitute resources is usually not possible, but in social systems substitutes are often possible (e.g. by constructing new social facilities for those that are lost). Should it not be possible to replace a resource, the resource is essentially irreplaceable e.g. red data species that are restricted to a particular site or habitat of very limited extent.

F. Consequence

The consequence of the potential impacts is a summation of above criteria, namely the extent, duration, intensity and impact on irreplaceable resources.

G. Probability of occurrence

The probability of the impact actually occurring based on professional experience of the specialist with environments of a similar nature to the site and/or with similar projects. Probability is described as low (improbable), medium (distinct possibility), and high (most likely). It is important to distinguish between probability of the **impact** occurring and probability that the **activity causing a potential impact** will occur. Probability is defined as the probability of the impact occurring, not as the probability of the activities that may result in the impact. The fact that an activity will occur does not necessarily imply that an impact will occur. For instance, the fact that a road will be built does not necessarily imply that it will impact on a wetland. If the road is properly routed to avoid the wetland, the impact may not occur at all, or the probability of the impact will be low, even though it is certain that the activity will occur.

H. Significance

Impact significance is defined to be a combination of the consequence (as described below) and probability of the impact occurring. The relationship between consequence and probability highlights that the risk (or impact significance) must be evaluated in terms of the seriousness (consequence) of the impact, weighted by the probability of the impact actually occurring. The following analogy provides an illustration of the relationship between consequence and probability. The use of a vehicle may result in an accident (an impact) with multiple fatalities, not only for the driver of the vehicle, but also for passengers and other road users. There are certain mitigation measures (e.g. the use of seatbelts, adhering to speed limits, airbags, anti-lock braking, etc.) that may reduce the consequence or probability or both. The probability of the impact is low enough that millions of vehicle users are prepared to accept the risk of driving a vehicle on a daily basis. Similarly, the consequence of an aircraft crashing is very high, but the risk is low enough that thousands of passengers happily accept this risk to travel by air on a daily basis.

In simple terms, if the consequence **and** probability of an impact is high, then the impact will have a high significance. The significance defines the level to which the impact will influence the proposed development and/or environment. It determines whether mitigation measures need to be identified and implemented and whether the impact is important for decision-making.

I. Degree of confidence in predictions

Specialists were required to provide an indication of the degree of confidence (low, medium or high) that there is in the predictions made for each impact, based on the available information and their level of knowledge and expertise. Degree of confidence is not taken into account in the determination of consequence or probability.

J. Mitigation measures

Mitigation measures are designed to reduce the consequence or probability of an impact, or to reduce both consequence and probability. The significance of impacts has been assessed both with mitigation and without mitigation.

K. Legal requirements

The specialist identified and listed the relevant South African legislation and permit requirements pertaining to the development proposals. Reference must be provided to the procedures required to obtain permits and describe whether the development proposals have the potential to trigger applicable licensing or permit requirements.

APPENDIX G

Results of hand auguring of duneslack wetlands

During the course of 2009, FCG conducted additional surveys of the duneslack wetlands associated with the broader Oyster Bay dunefield, extending well beyond the Eskom-controlled site boundaries. During these surveys, wetlands across an 8.4 km length of the dunes, moving eastward from a point 800m west of the eastern site boundary over the dunes were visually assessed, and 13 of these wetlands were augered, again using a hand auger. Augering was carried out in September 2009, during a particularly dry period in the Eastern Cape, with few of the wetlands that were inundated throughout 2007 and 2008 being inundated at the time of the site visit. Table G1 summarises the findings at each augured area, while the locations of the augured sites are shown in Figure G1.

Although hand augering of the sites listed in Table G1 could arguably have missed deeper aquitards, data from the only two boreholes sunk in the dunefield (Figure G2) indicate water to within 2m and 2.7m of the surface at these points, continuing down the full depth of the well (25 mbgl). Although the latter borehole log (Figure G2B) does indicate the presence of "clayey" material between 22 and 24m bgl, the water level log indicates water below this level, suggesting that the clay layer is probably localised and that the water level recorded is in fact part of the Algoa aquifer itself. Borehole log data for site THY-MAR14 in the dunefield immediately north of the Langefonteinvlei indicate that at the time of sampling, standing water at this site occurred in the dune from 65 mamsl down to at least 40 mamsl (Figure G2). SRK (2009) describes groundwater level elevations in the Algoa aquifer to the north of the EIA Corridor as varying between 17 and 33 mamsl. Based on these data, it is not improbable that the data reflect the regional water table, rather than perching and, moreover, that the Langefonteinvlei may be at or very close to the water table.

Table G1 Observations from the September 2009 field survey of duneslack wetlands (September 2009)

All augering carried out using a handheld auger. All sites located in areas known to have provided inundated wetland habitat during the past two years – either based on visual evidence or past site visits. WP=waypoint number, as shown in Figure G1.

WP	Standing water?	Presence of aquitard?	Comment
3	Yes	No	Sand to >0.8m bgl
21	no - inundated throughout 2008	No	soil damp to 1.2m; slight layer of "muck[8]" on surface
23	no - inundated throughout 2008	No	permanently vegetated wetland; damp at 0.75m bgl; fine sands
24	no - inundated throughout 2008	No	permanently vegetated wetland; muck layer (1cm deep); damp at 0.8m bgl; fine sands
37	no - inundated throughout 2008	Yes	very localised patch of clayey material at 0.4m bgl; saturated below clay
38	no - inundated throughout 2008	No	same wetland as WP37: sandy; saturated from surface
39	no - inundated throughout 2008	No	same wetland as WP37: sandy; saturated from surface
41	no - inundated throughout 2008	No	saturated (standing water) from 0.2m bgl
46	no - inundated throughout 2008	No	saturated (standing water) from 0.2m bgl
44	no - inundated throughout 2008	Slight	permanently vegetated wetland; soil slightly clayey; damp to 0.8m
45	no - inundated throughout 2008	Yes	permanently vegetated wetland; slight clay layer at 0.2m; then saturated
52	Yes	No	sand to >0.8m bgl
60	No	No	permanently vegetated wetland; sandy; saturated from 0.4m
186	No	No	Soil sandy; slight mottling evident at .2m bgl; Saturated at 0.35m bgl

[8] The term "muck" refers to the accumulation of organic debris, usually algae or other fine plant material that remains as a defined layer on the surfaces of wetlands as they dry out (USACE 2006).

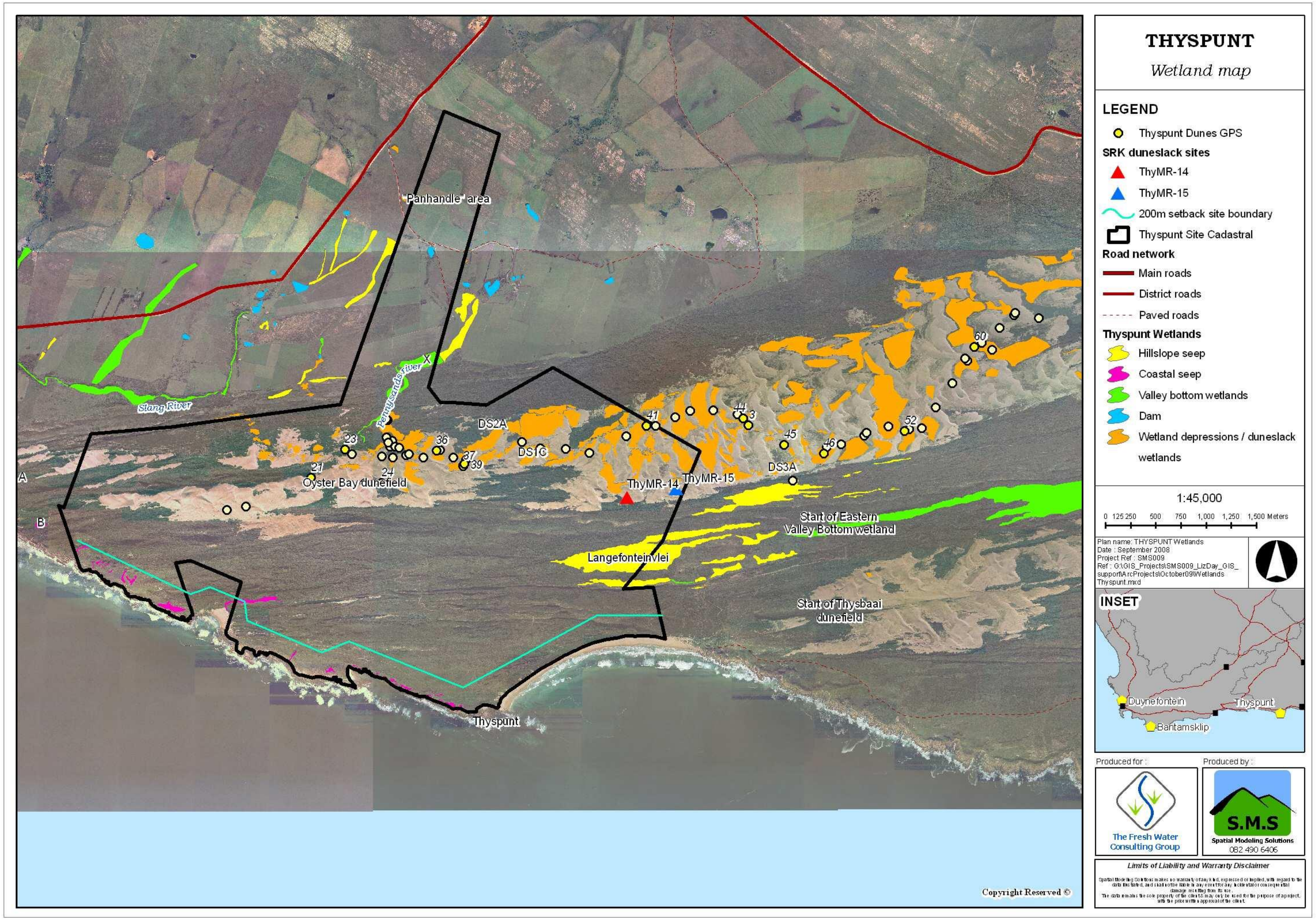
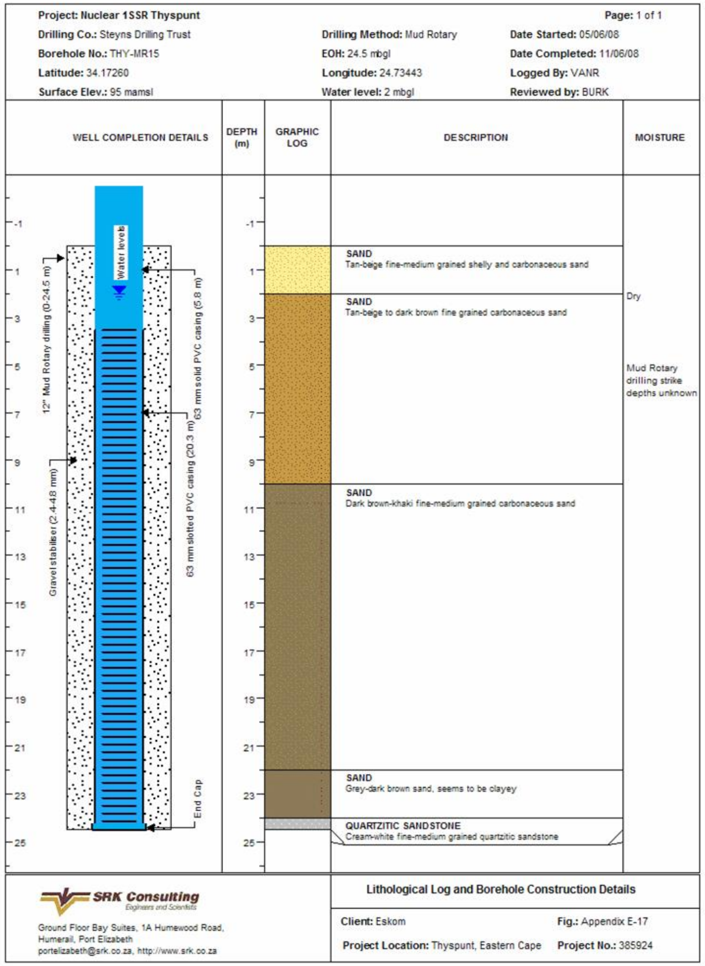


Figure G1 **Locations of spot site assessments and/or auger positions on the main Oyster Bay dunefield, in September 2009.** Observational data from hand-augered sites provided in Table G1. Sites THY-MAR14 and THY-MAR15 comprise SRK borehole monitoring sites. Borehole log data are shown in Figure G2.

A



B

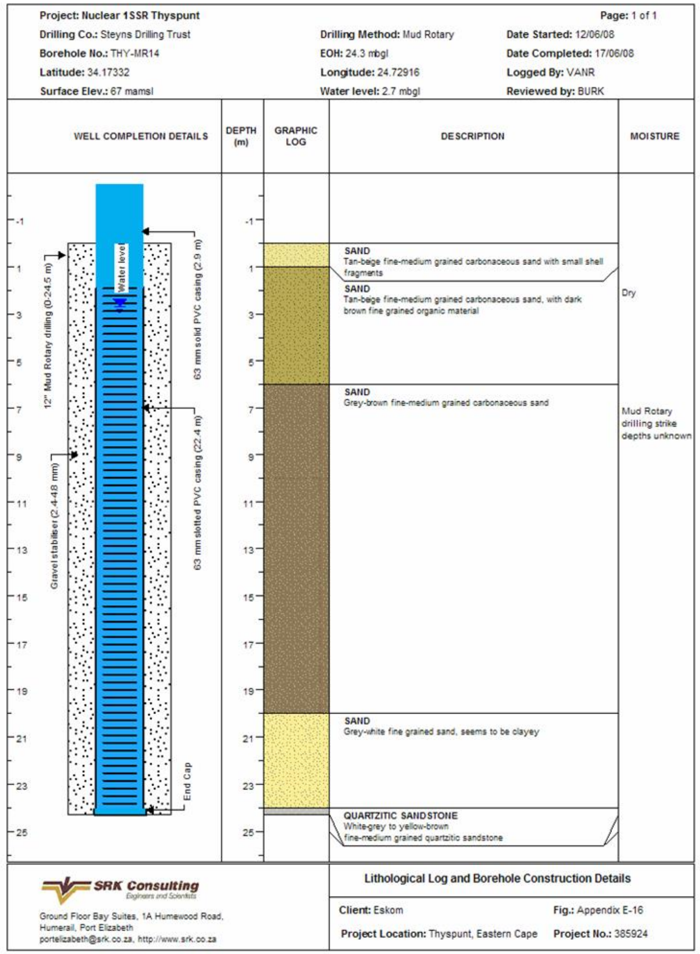


Figure G2 **Logged borehole data from two sites in the Oyster Bay dunefield. Site locations as shown in Figure G1. Data courtesy SRK.**